Charleston Takes on Sea Level Rise: Strategies, Projects, Funding, and Progress

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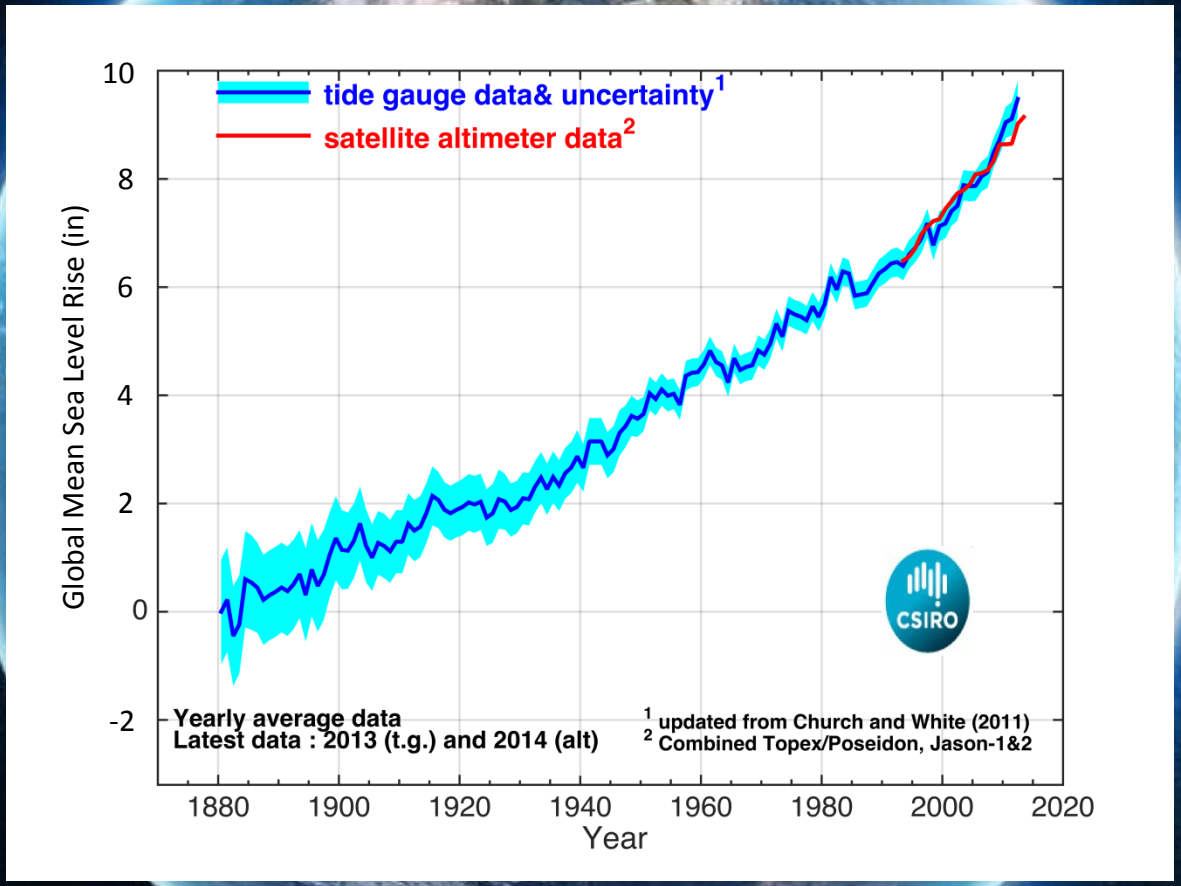
Sea Grant
S.C. Sea Grant Consortium

LWV

City of Charleston


tide gauge data& uncertainty[1]
satellite altimeter data[2]
Global Mean Sea Level Rise (in)
10
8
6
4
2
0
-2
1880
1900
1920
1940
1960
1980
2000
2020
Year
CSIRO
Yearly average data
Latest data : 2013 (t.g.) and 2014 (alt)
[1] updated from Church and White (2011)
[2] Combined Topex/Poseidon, Jason-1&2

What drives global sea level change?

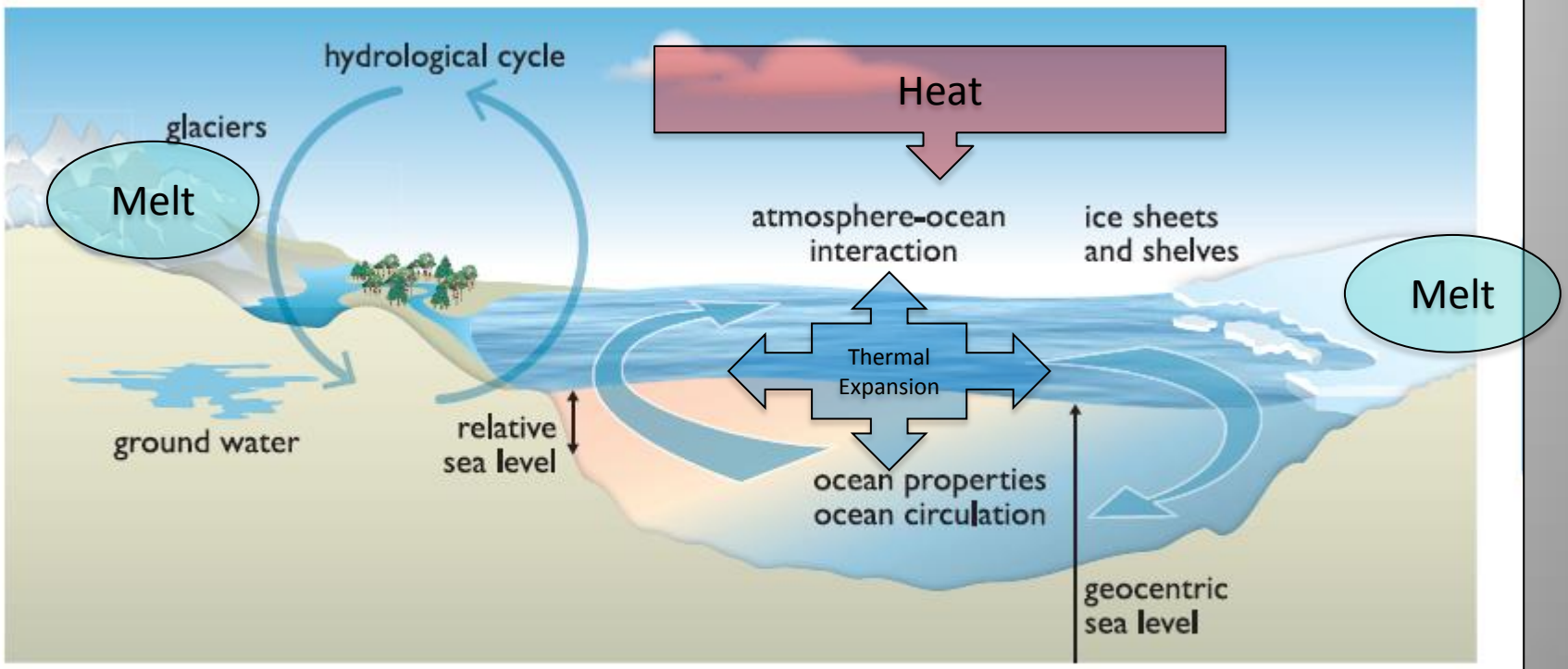
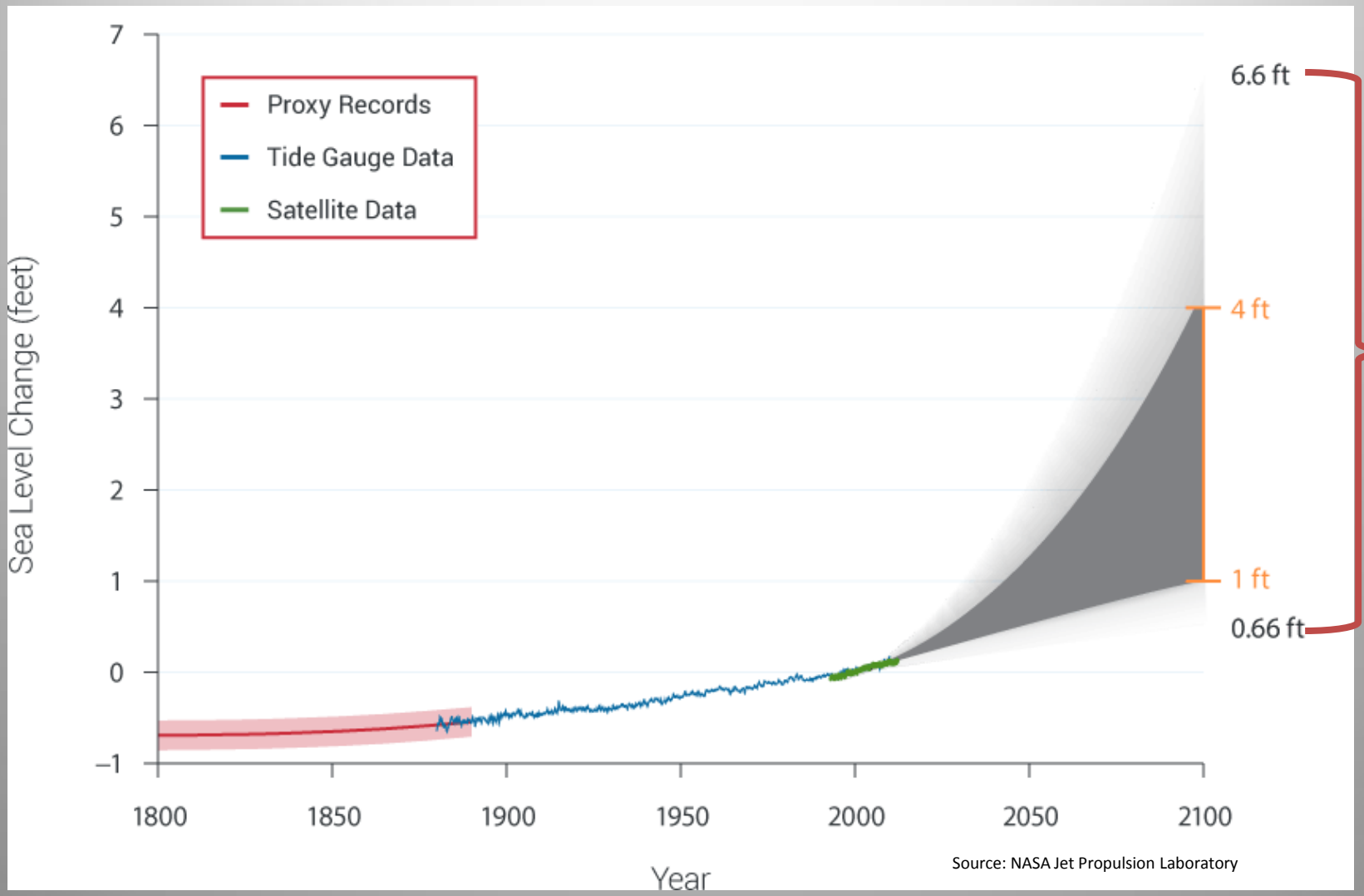


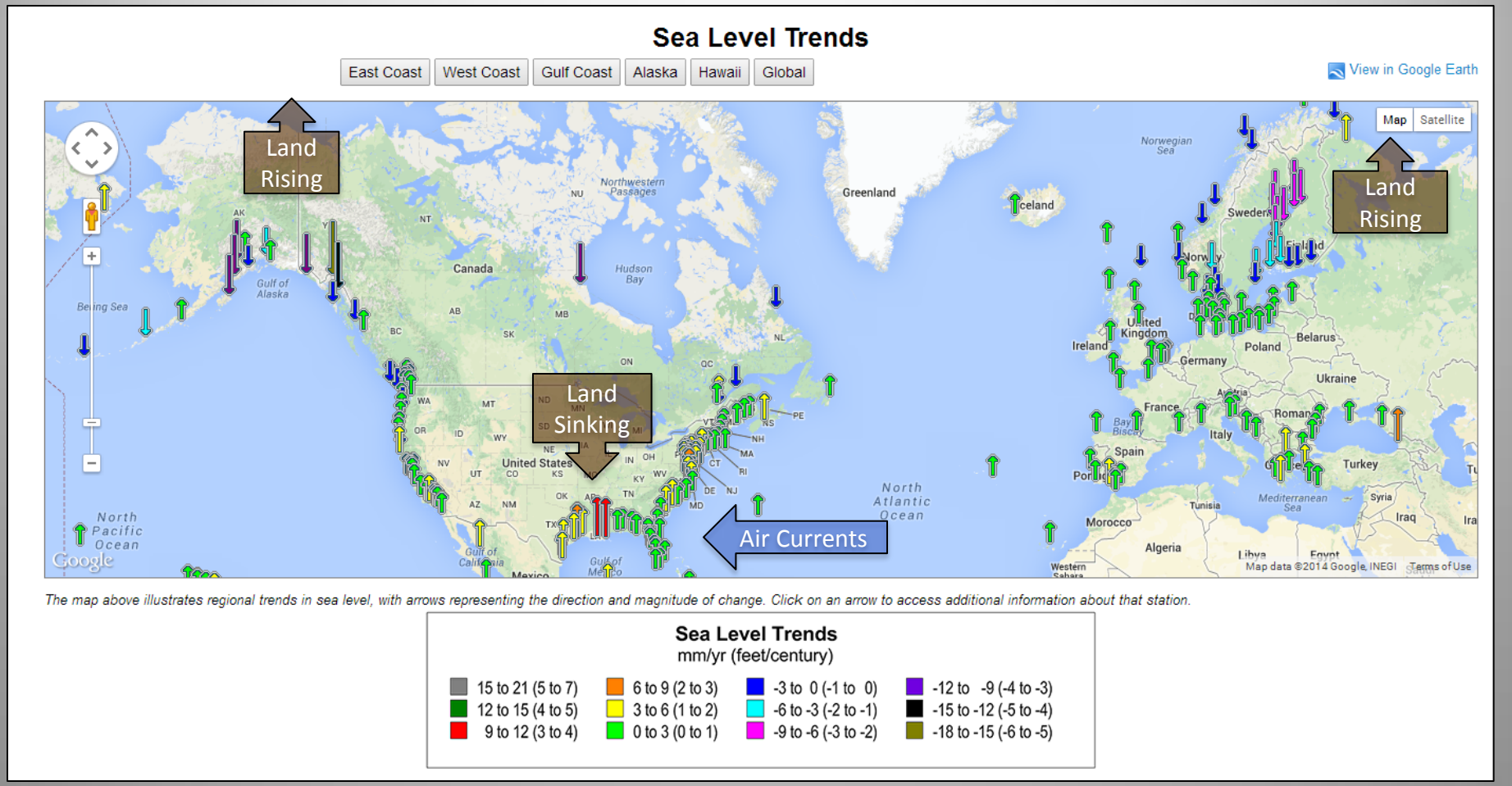
Figure 13.1 | Climate-sensitive processes and components that can influence global and regional sea level and are considered in this chapter. Changes in any one of the components or processes shown will result in a sea level change. The term 'ocean properties' refers to ocean temperature, salinity and density, which influence and are dependent on ocean circulation. Both relative and geocentric sea level vary with position. Note that the geocenter is not shown.

Source: 2014 National Climate Assessment

Wide range of future SLR projections due to uncertainty of ice melt



What drives local sea level change?



The map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an arrow to access additional information about that station.

Sea Level Trends
mm/yr (feet/century)

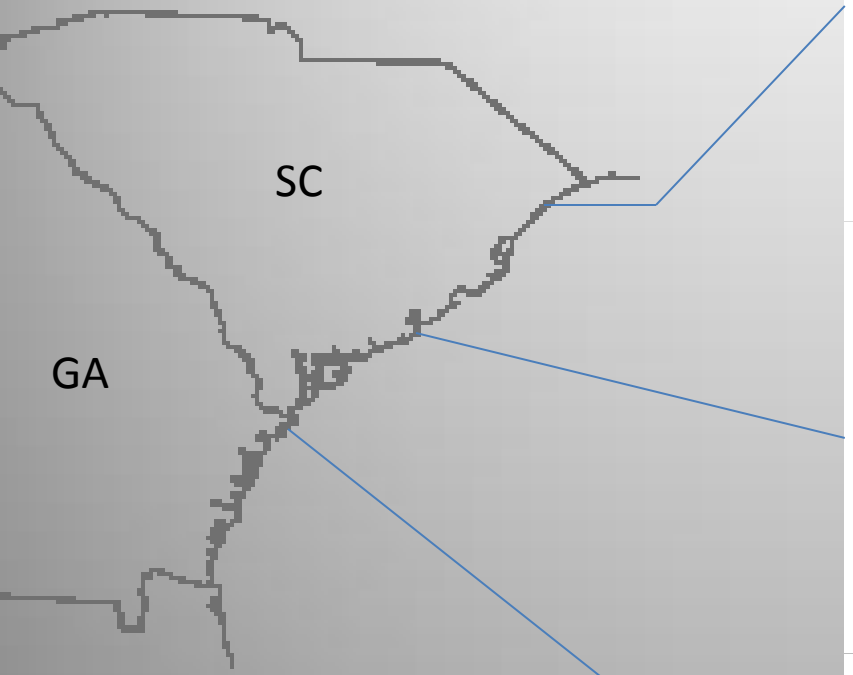
15 to 21 (5 to 7)	6 to 9 (2 to 3)	-3 to 0 (-1 to 0)	-12 to -9 (-4 to -3)
12 to 15 (4 to 5)	3 to 6 (1 to 2)	-6 to -3 (-2 to -1)	-15 to -12 (-5 to -4)
9 to 12 (3 to 4)	0 to 3 (0 to 1)	-9 to -6 (-3 to -2)	-18 to -15 (-6 to -5)

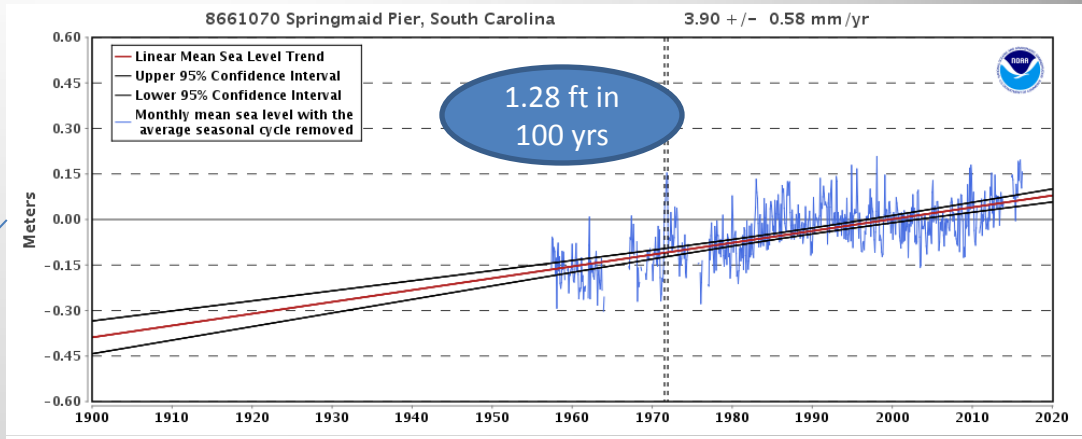
Global sea level change

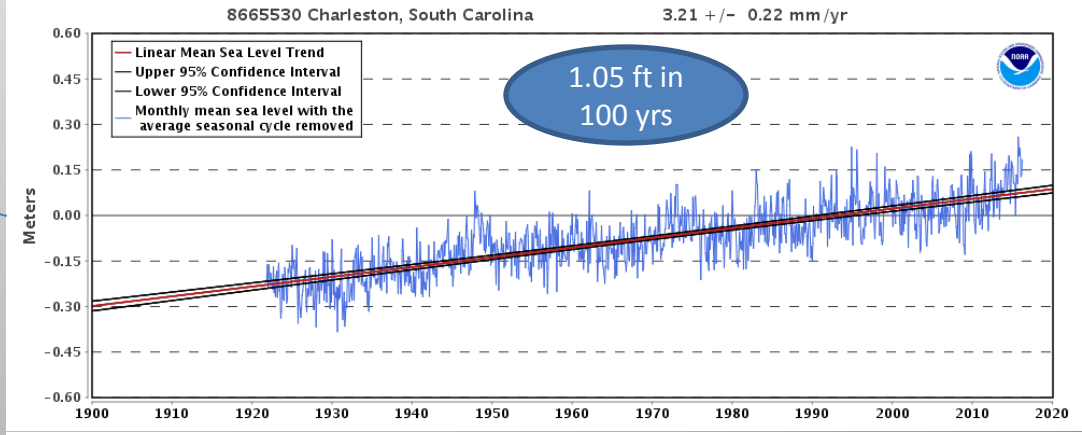
Land movement

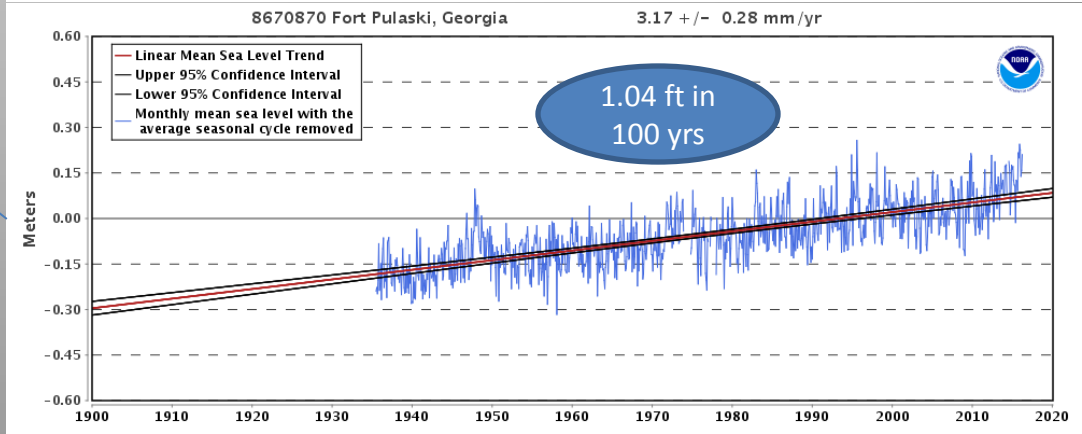
Wind-driven tidal patterns

Local trends

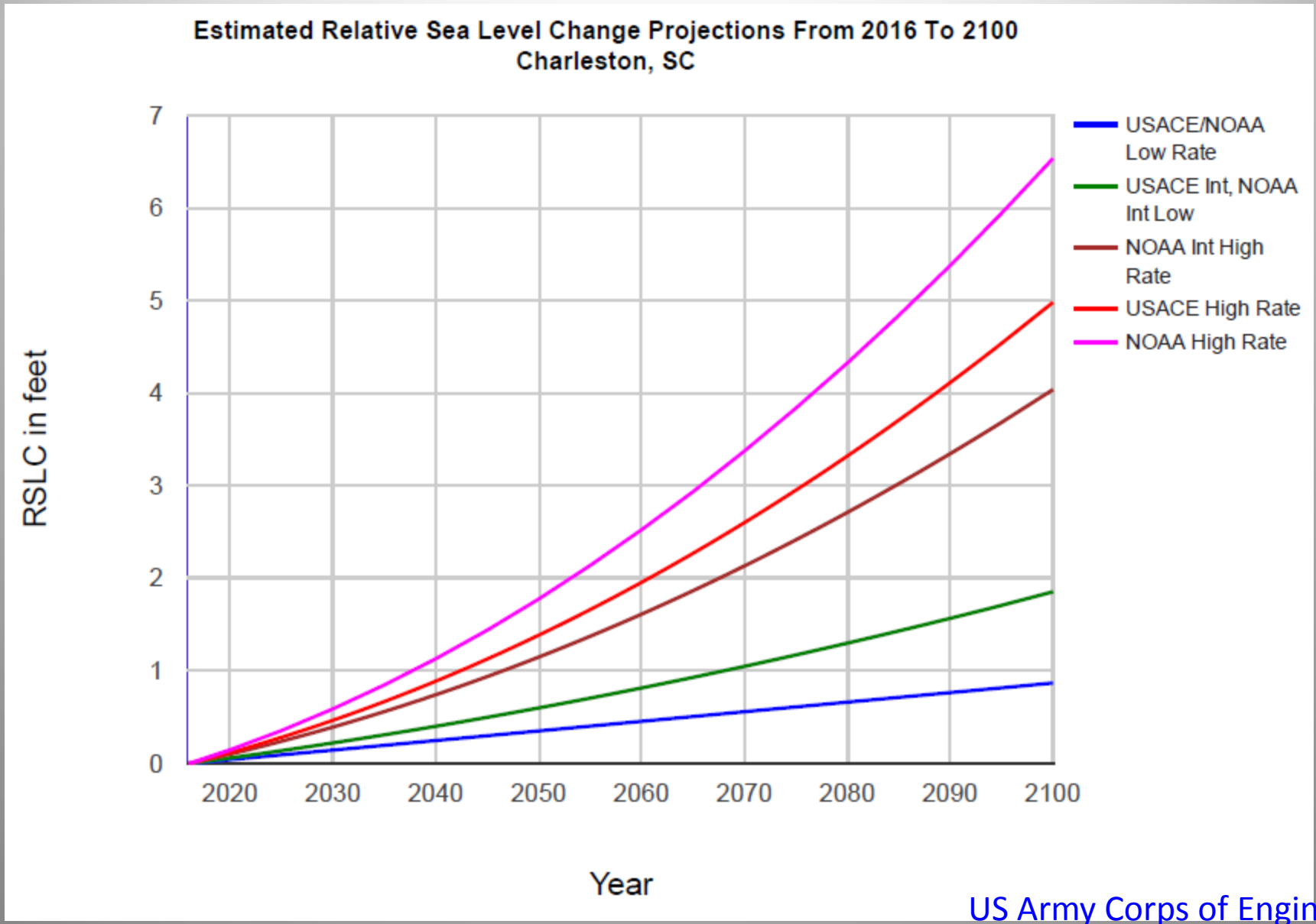






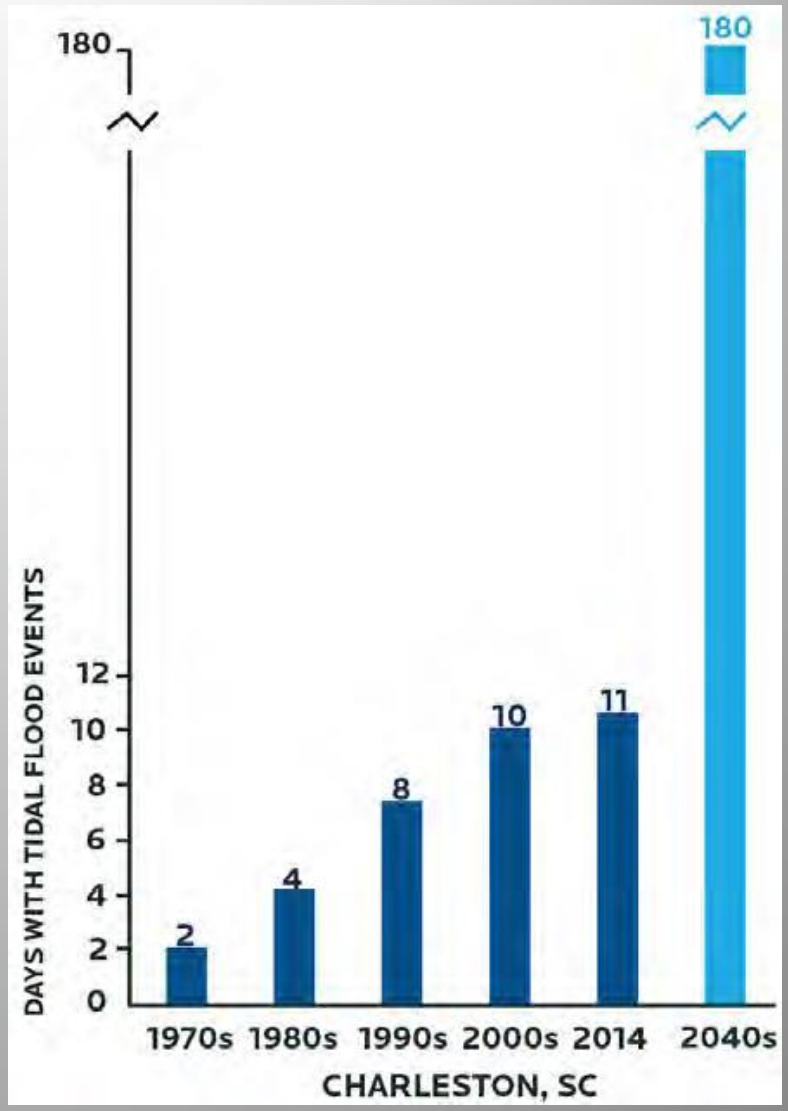


Future predictions



[US Army Corps of Engineers Sea Level Rise Calculator]

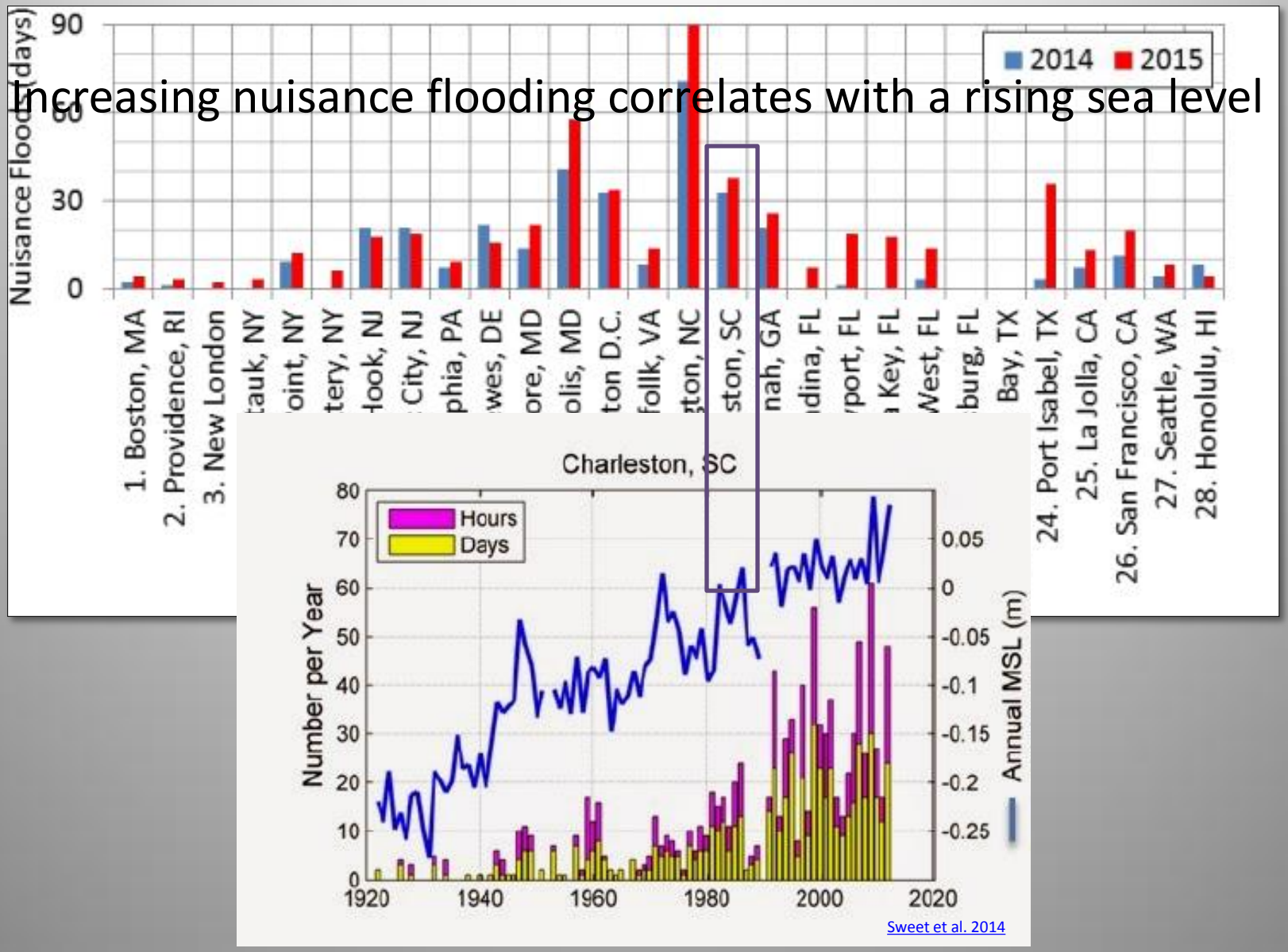
Sea Level Rise in Action: Nuisance Flooding



SOURCES: UCS Analysis; Morales and Alsheimer 2014; NOAA Tides and Currents 2013.

Sea Level Rise in Action: Nuisance Flooding

Increasing nuisance flooding correlates with a rising sea level



Photos courtesy of SC DHEC/MyCoast

October 2015 Flood Event

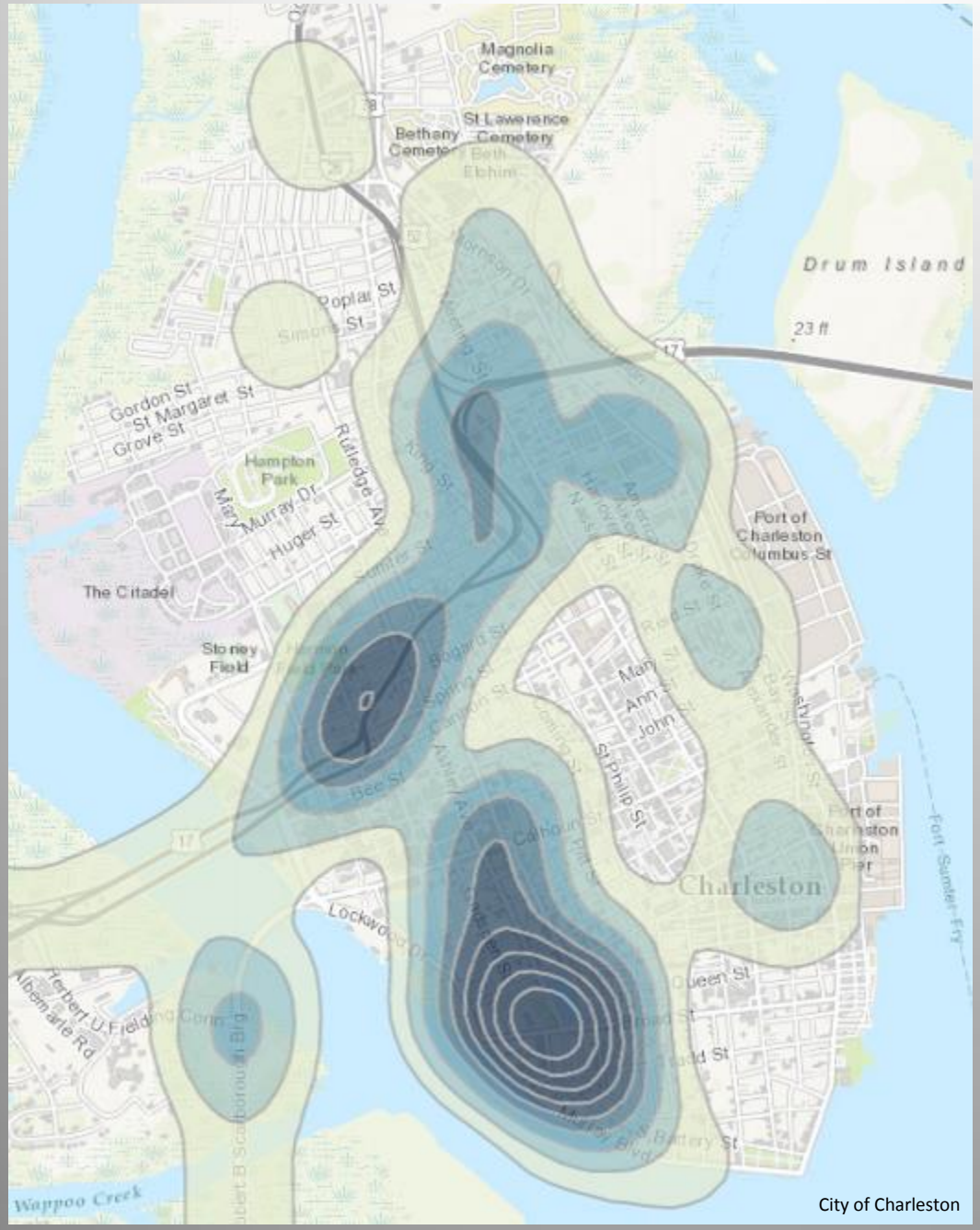
Record Setting Rainfall

23.76 inches near **Clark Sound** on James Island in Charleston (Oct. 1-5, 2015)

22.04 inches near the **Whitehouse Plantation** area of James island in Charleston (Oct. 2-6, 2015)

21.57 inches near **Wappoo Creek** in Charleston (Oct. 2-6, 2015).

Road closures during October 2015 rainfall event



157 total* roads closed

*some roads closed more than once due to tidal cycles

Hurricane Matthew - October 2016

In the Charleston region:

Peak wind gusts
75-80 mph

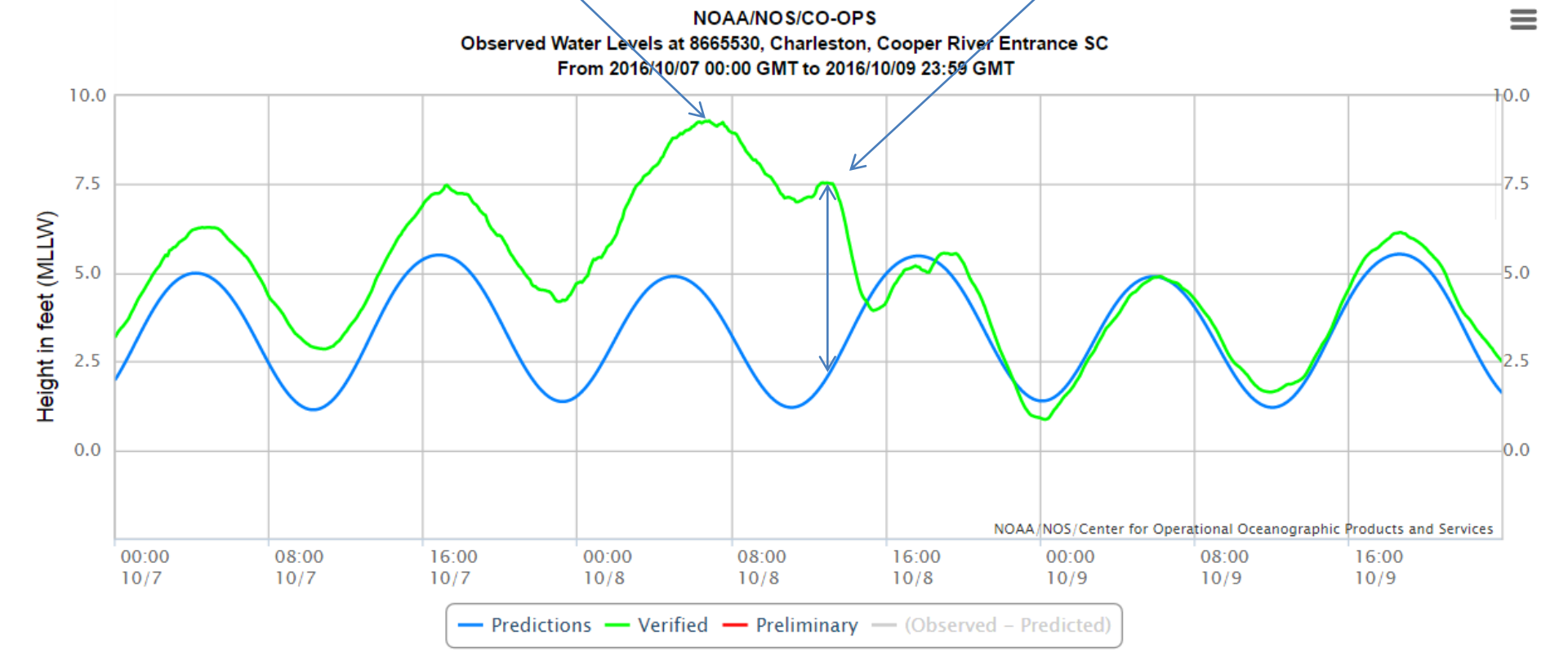
Total rainfall
8-11 inches

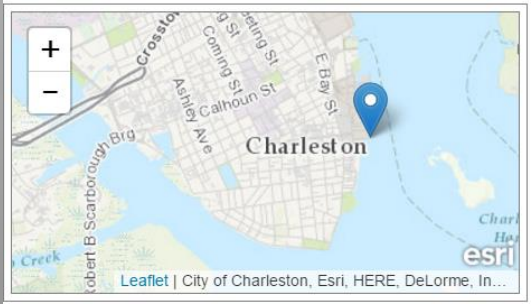
Storm surge
6.2 feet

3rd highest tidal level ever recorded in Charleston of 9.29 feet

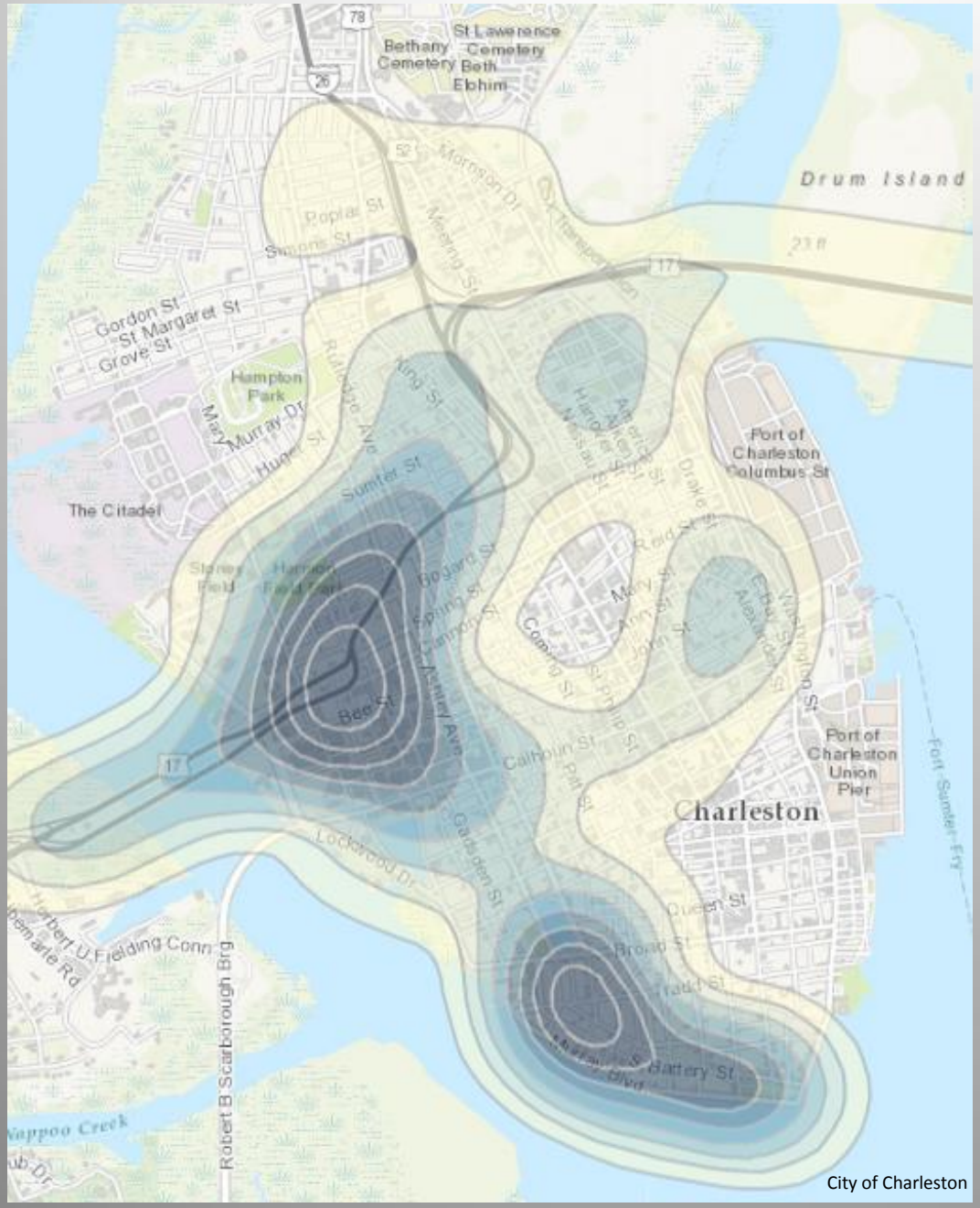
Matthew landfall (**not** at high tide); storm surge of 6.2 feet

Station Info | Tides/Water Levels | Meteorological Obs. | Phys. Oceanography | PORTS®





Road closures during October 2015 rainfall event



137 total* roads closed

*some roads closed more than once due to tidal cycles

Official NFIP Site - Flood

https://www.floodsmart.gov/floodsmart/

Call toll free: 1-888-379-9531 or have us call you

FloodSmart.gov
The official site of the NFIP

Search FloodSmart.gov GO!

- HOME
- FLOOD RISKS
- UNDERSTANDING FLOOD MAPS
- RESIDENTIAL COVERAGE
- COMMERCIAL COVERAGE
- POLICYHOLDER RESOURCES
- PARTNER RESOURCES
- INSURANCE AGENT RESOURCES
- ABOUT THE NFIP

Hurricane Season | National Preparedness Month | Get the FEMA App | Protect What Matters | About Flood Maps

LATEST NEWS

Learn what you can do to keep your family and property safe before, during, and after a flood.

Typically, there's a 30-day waiting period from date of purchase before

WHAT'S MY FLOOD RISK

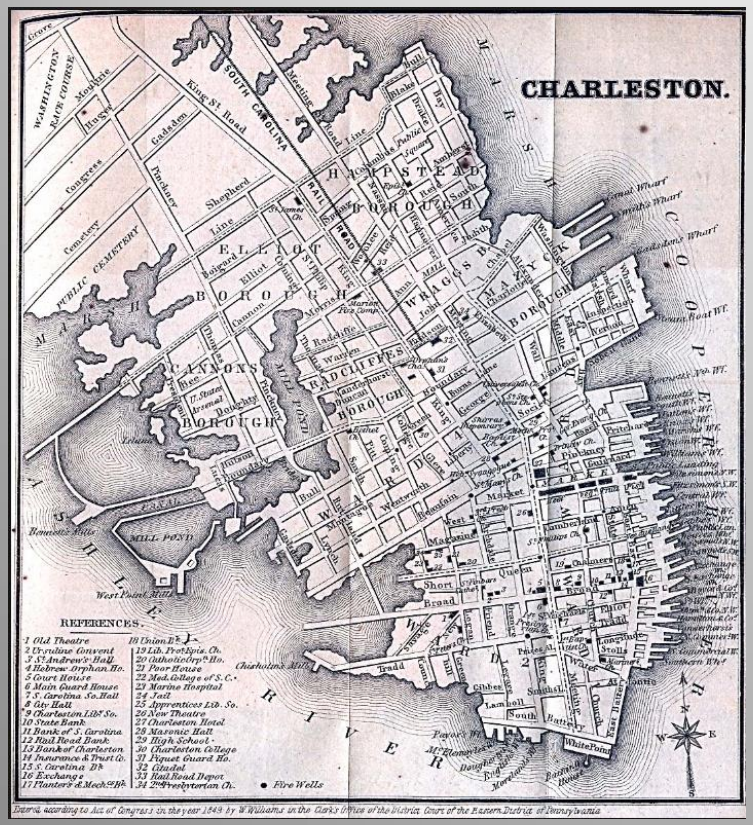
Visit FEMA's Flood Map Service Center to locate your flood map to help determine your flood risk.

Sea Level Rise
STRATEGY

A Guiding Principle

Charleston

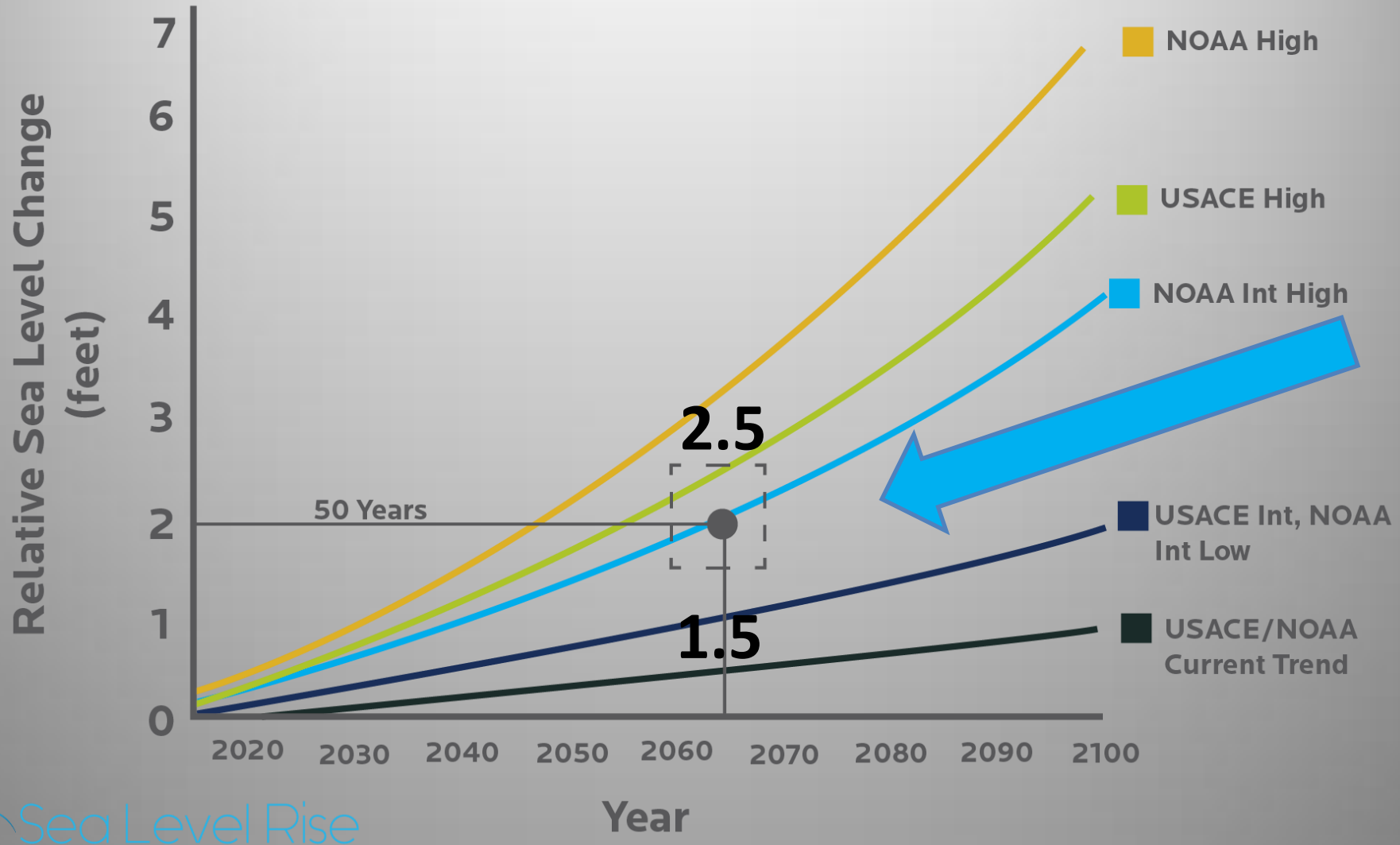
- 1849



- 2016 w 2.5 ft slr

Sea Level Rise STRATEGY

Sea Level Rise
STRATEGY



Sea Level Rise
STRATEGY

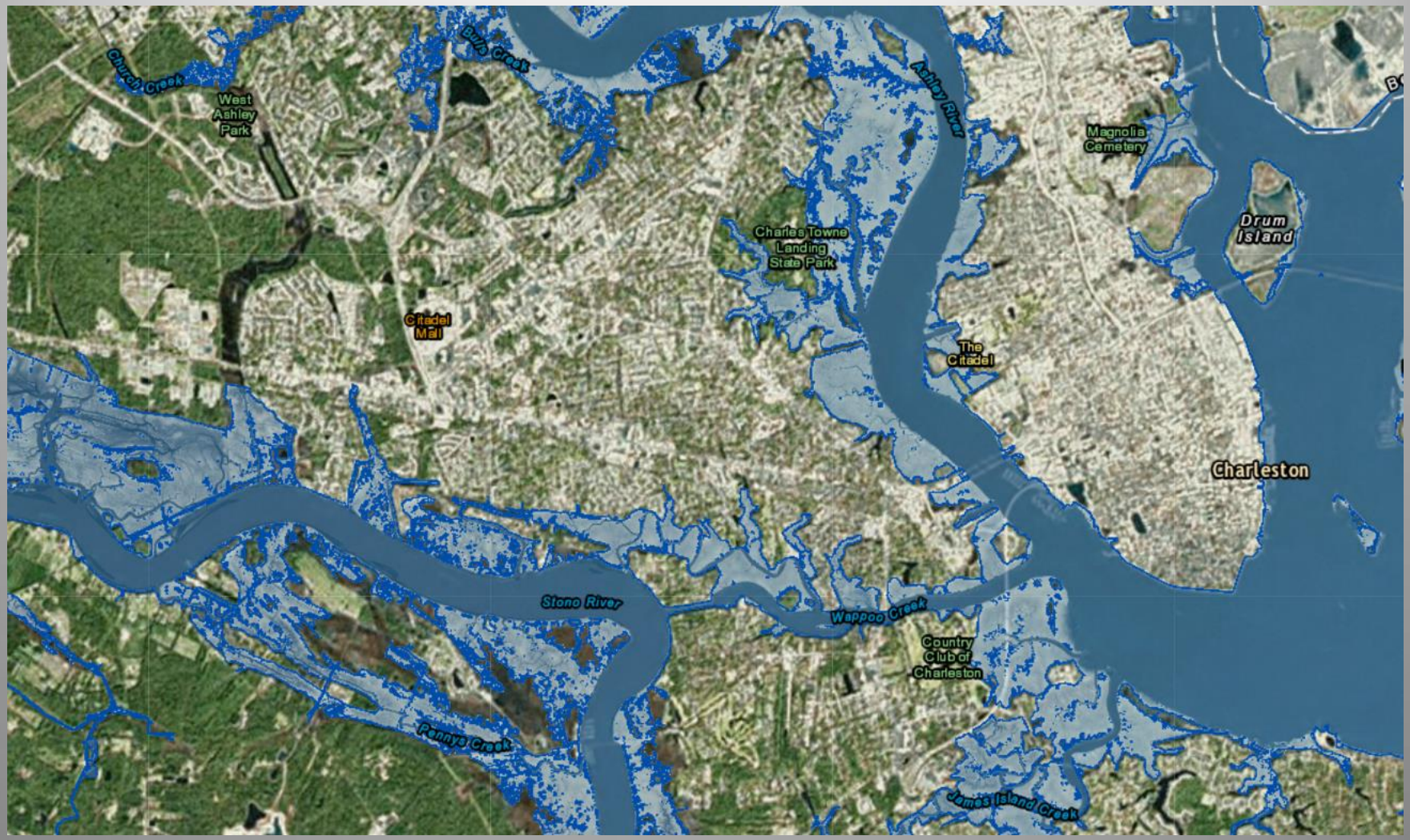
SLR Viewer

- Google sea lever rise viewer Charleston

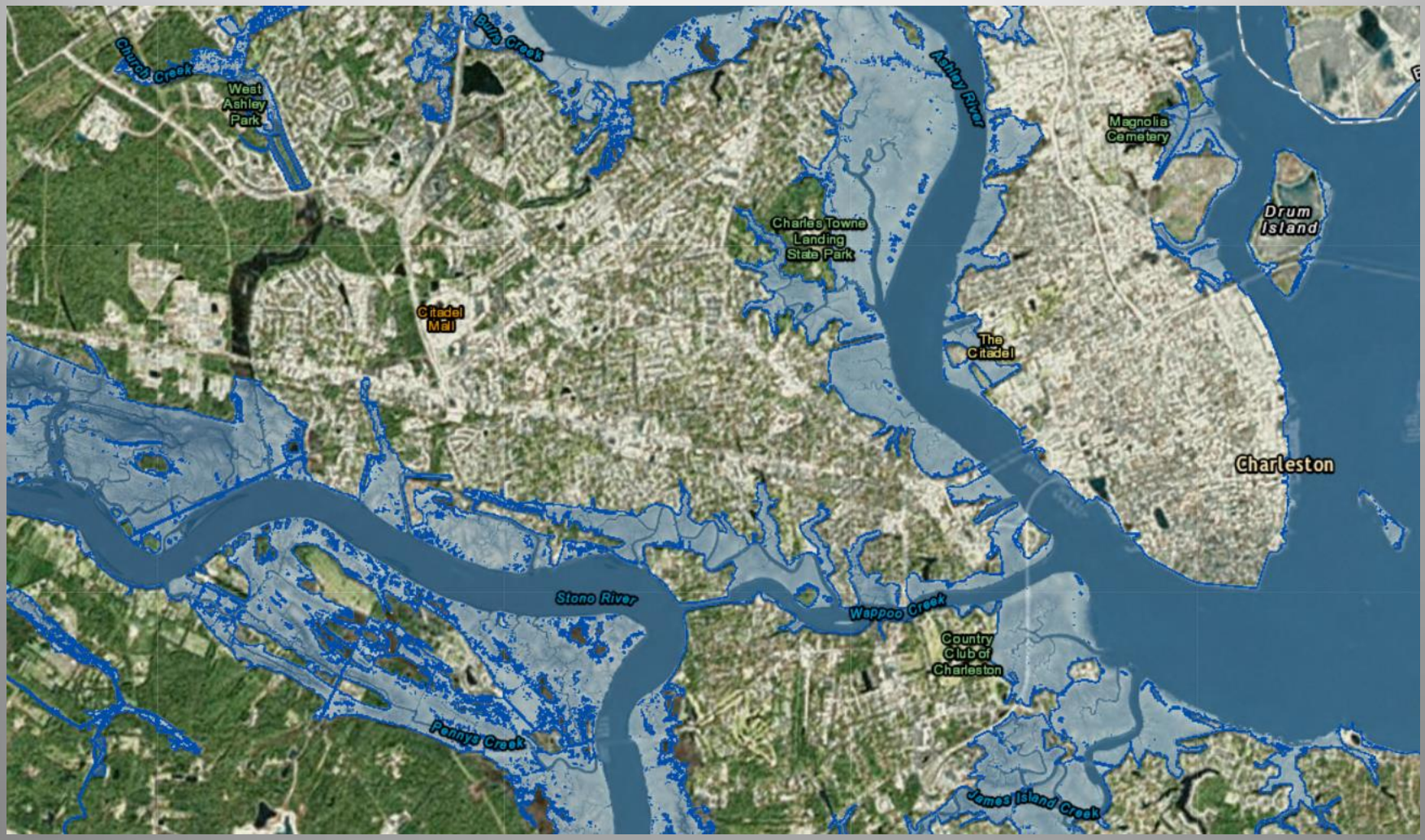
- http://gis.charleston-sc.gov/interactive/slr/

Sea Level Rise STRATEGY

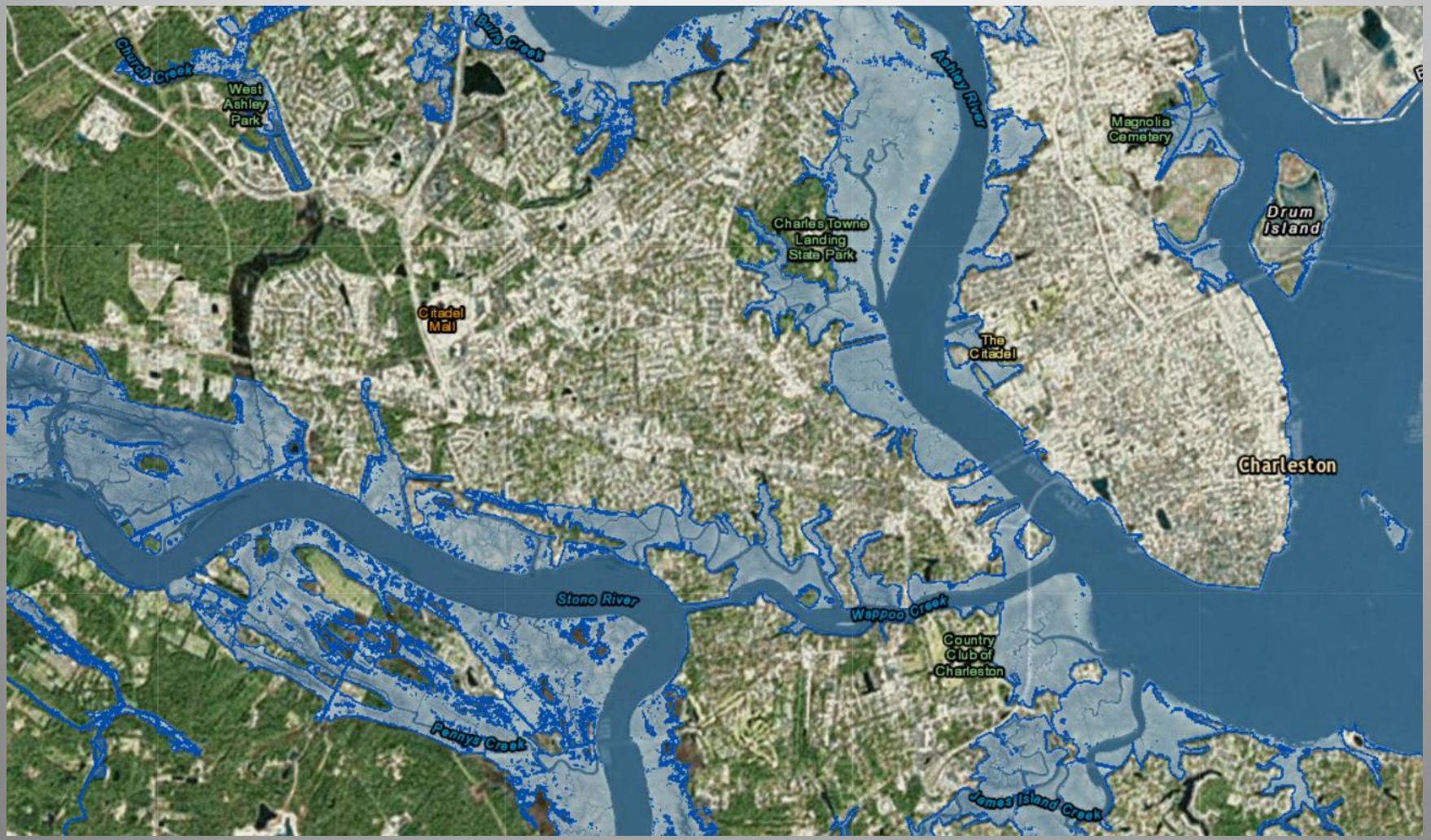
SLR Viewer 0 feet



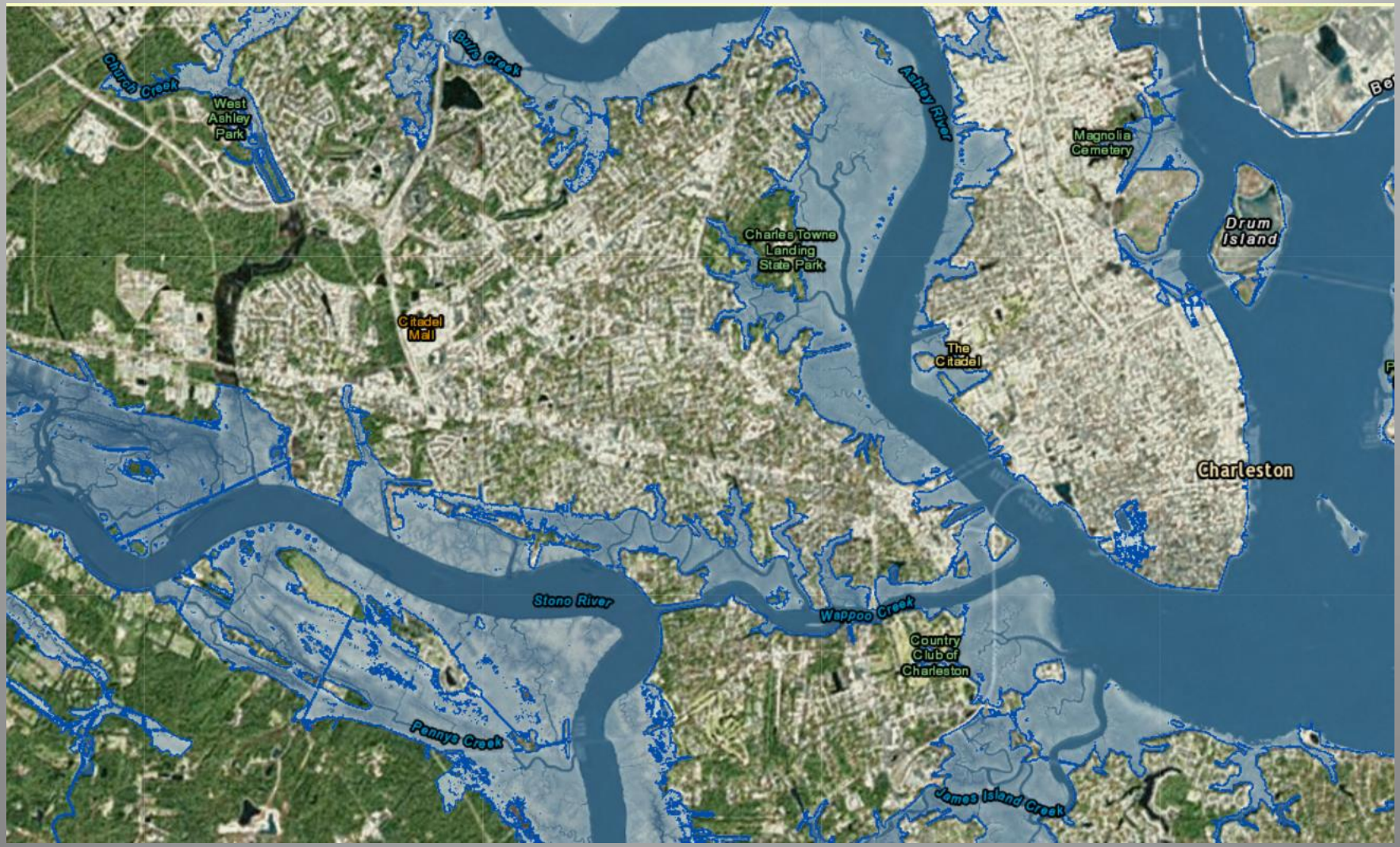
SLR Viewer .5 feet



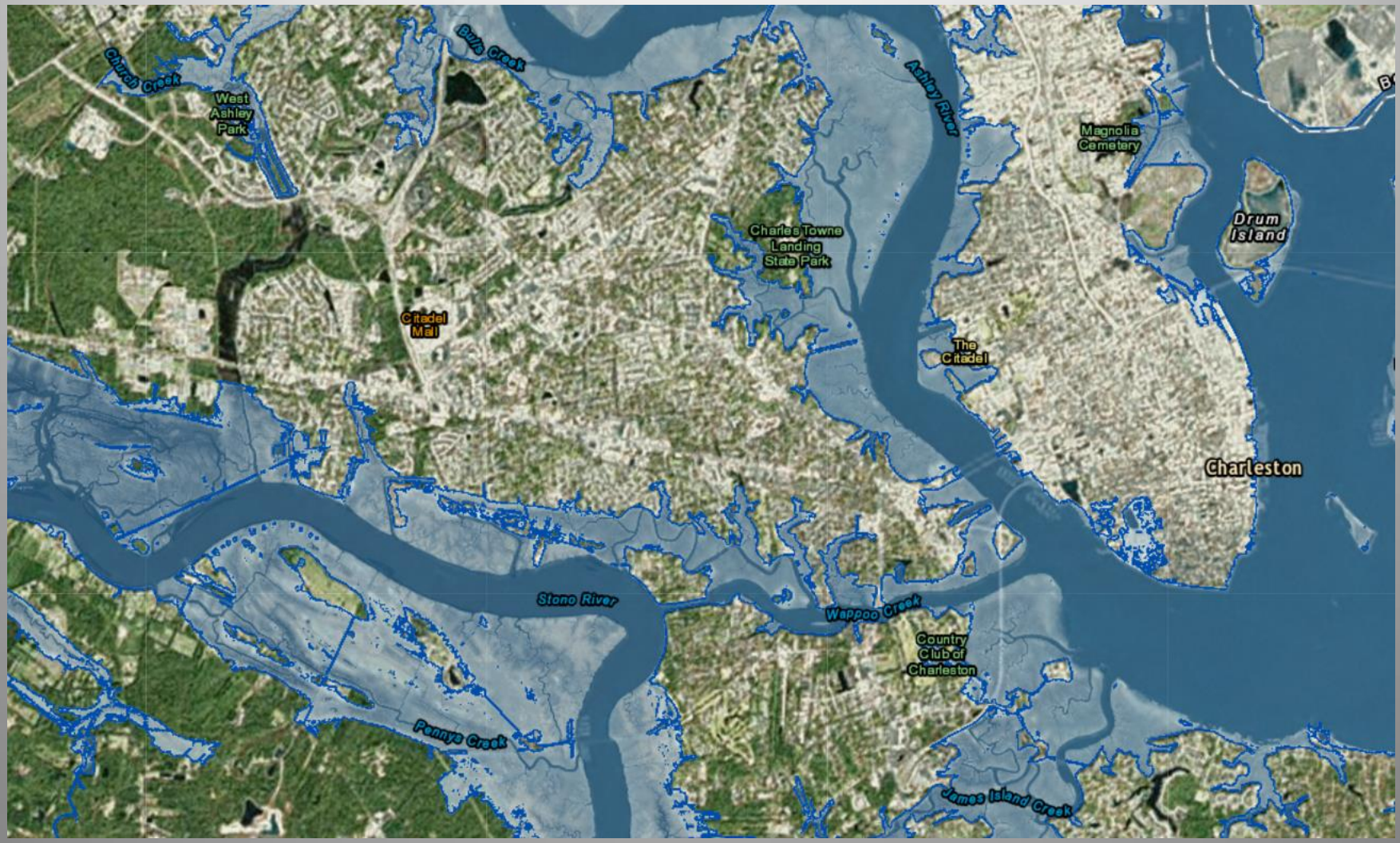
SLR Viewer 1 feet



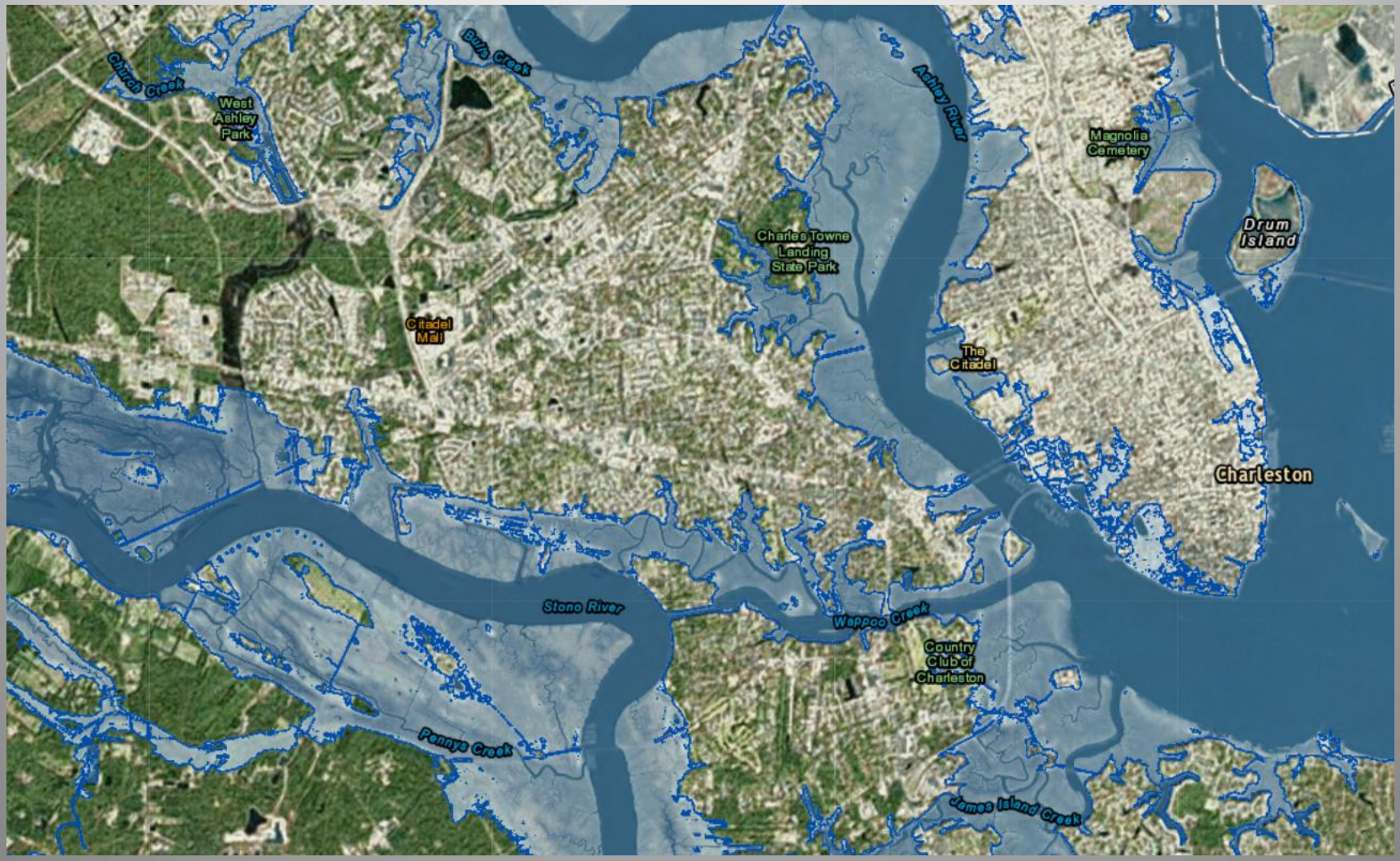
SLR Viewer 1.5 feet



SLR Viewer 2 feet



SLR Viewer 2.5 feet



Strategies

Of the 76 strategies recommended in the City of Charleston's Sea Level Rise Strategy which was adopted in 2016,

27 are in Progress

Sea Level Rise STRATEGY

Sea Level Rise STRATEGY

REINVEST

RESPOND

READY

Reinvest

Reinvestment actions will provide **long-term** improvements to public health, safety and quality of life through additional **investment in infrastructure and physical modifications**.

Sea Level Rise STRATEGY

Ready

Readiness type actions will **enable prevention and preparedness** through **continued planning, monitoring and identification of changing vulnerabilities and risks**.

Sea Level Rise STRATEGY

Respond

Response actions will improve our response to, communication during, and management of flooding and related events to **minimize service disruptions and to ensure public safety and quality of life**.

Sea Level Rise STRATEGY

Ready – In Progress

- Collaborate with the Charleston Resilience Network for latest information, grants, regional perspective etc.
- CRN: Public and private sector stakeholder organizations with the Charleston, SC, that have a collective interest in the resilience of communities,
  - works to foster a unified strategy and
  - provide a forum to share science-based information,
  - educate stakeholders and
  - enhance long-term planning decisions that result in resilience.

  - **NOAA Resilience Grant**
    - Sea Grant
    - Lowcountry Hazards Center

Credit: USDA

Sea Level Rise STRATEGY

Ready – Proposed

- Develop tools to monitor and gauge the impact of flood events on the community
  - monitor and gauge impact of flood events
    - increased commute time
    - reduced income
    - effectiveness of City response
  - quantify impacts to business owners and managers
    - hours closed
    - income and productivity lost

EXAMPLE: $1.53 billion over 50 years damages and lost wages Septima Clark Parkway In 2009 $

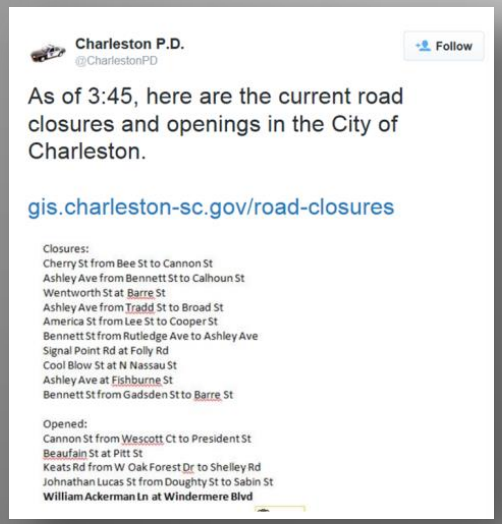
Sea Level Rise STRATEGY

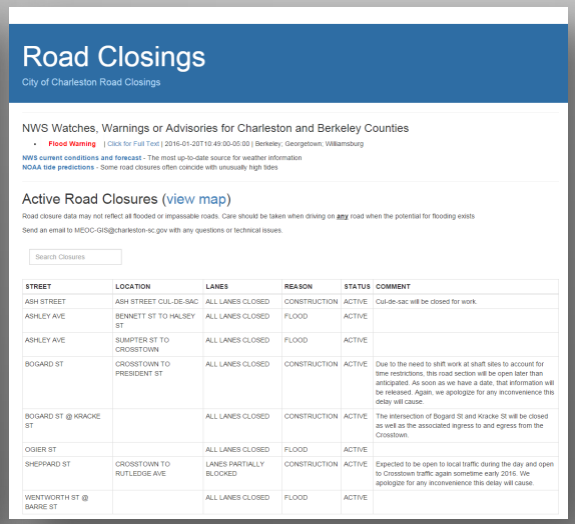
Ready - Proposed and In Progress

- Evaluate and assess impact of sea level rise on future development
  - Study zoning code to promote development that minimizes SLR
  - Incentivize Low Impact Development Best Management Practices
  - Revise maximum % impervious surface,
  - Encourage open space connectivity to marshes and creeks
  - **Encourage best practices for hard and landscape features that absorb, sustain, cleanse and release water**
  - Study zoning changes to encourage retrofits of existing buildings and construction of new resilient buildings in the 100 year floodplain

Respond – In Progress

- Enhance and promote real time flood incident information
  - Install flood gauge devices in repetitive flood area
  - Enhance current use technology for awareness and management of flooded roadways

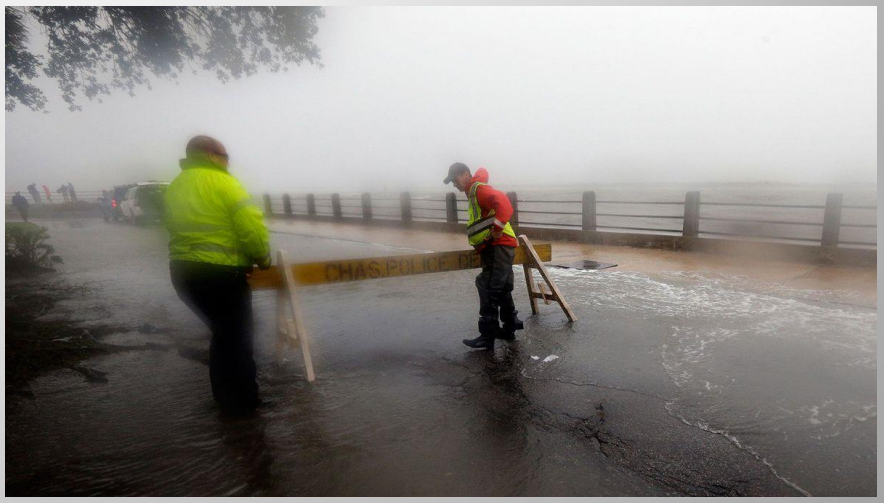




Sea Level Rise STRATEGY

Respond – In Progress

- Assess public safety resources
  - Identify and acquire appropriate response assets for public safety agencies **to secure flooded roadways**
  - Acquire additional **rescue equipment,** personnel and training for our first responders



Sea Level Rise STRATEGY

Respond – In Progress and Proposed

- Review/develop plans to minimize loss
  - Develop a formal City flood parking plan to prevent vehicle loss with appropriate signage/wayfinding
  - Promote best routes, parking plans, insurance programs, FEMA tools

Reinvesting Infrastructure

League of Women Voters

November 14, 2016

Reinvest –

- Reinvestment actions will provide long-term improvements to public health, safety and quality of life through additional investment in infrastructure and physical modifications.
- Three categories with 37 initiatives under Reinvestment

Sea Level Rise STRATEGY

Reinvest –

- **Evaluate the impact of SLR and prioritize improvements (include compounding effects such as rain bombs and hurricanes)**
  - Maintain a relationship with the scientific community
- **Establish more appropriate standards to protect public and private investments**
  - Consider additional freeboard for new structures
  - Adopt stormwater design standards that take SLR into account
- **Establish programs to address specific solutions for repetitive flooding areas**
  - Prioritize capital projects and continue investment in infrastructure that improves drainage and reduces flooding.
  - Evaluate impact of SLR on public infrastructure and prioritize improvements
  - Improve stormwater drainage
  - Utilize green infrastructure solution

Sea Level Rise STRATEGY

Why Does It Flood?

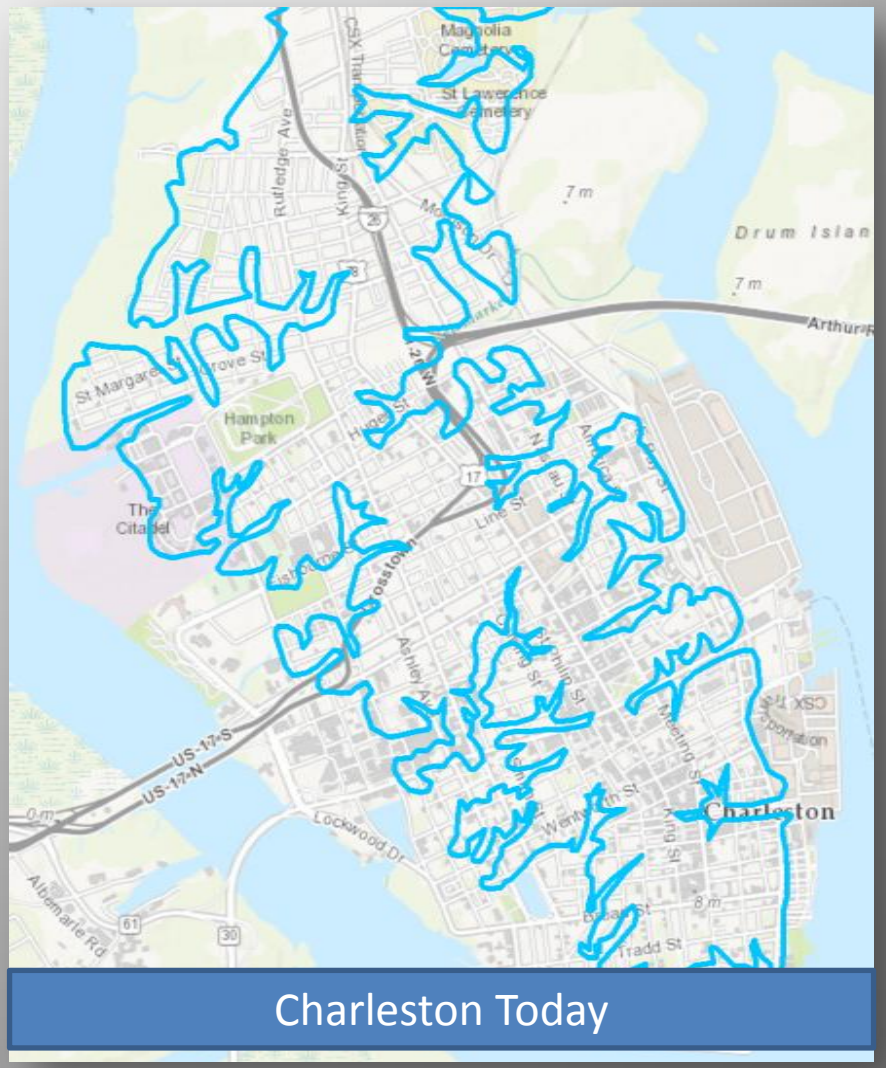
Why Does It Seem Like Charleston Always Floods When It Rains?

The Challenges of Draining a City That is Low, Flat, and Next to the Ocean

http://www.charleston-sc.gov/index.aspx?NID=588

Charleston Geography

Original High Tide Water Lines

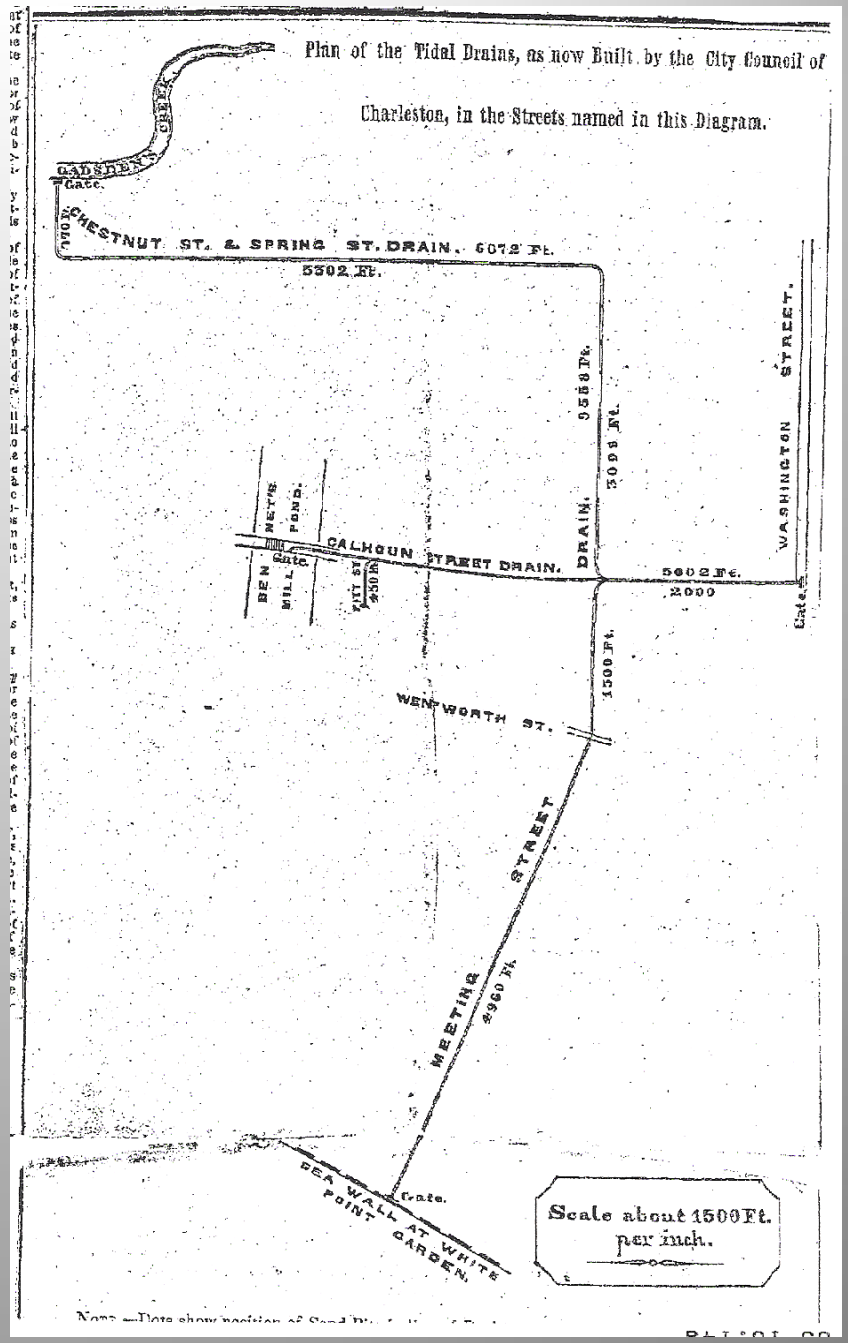


Charleston Today

1837 - Mayor's Proposal to Drain the City of Charleston

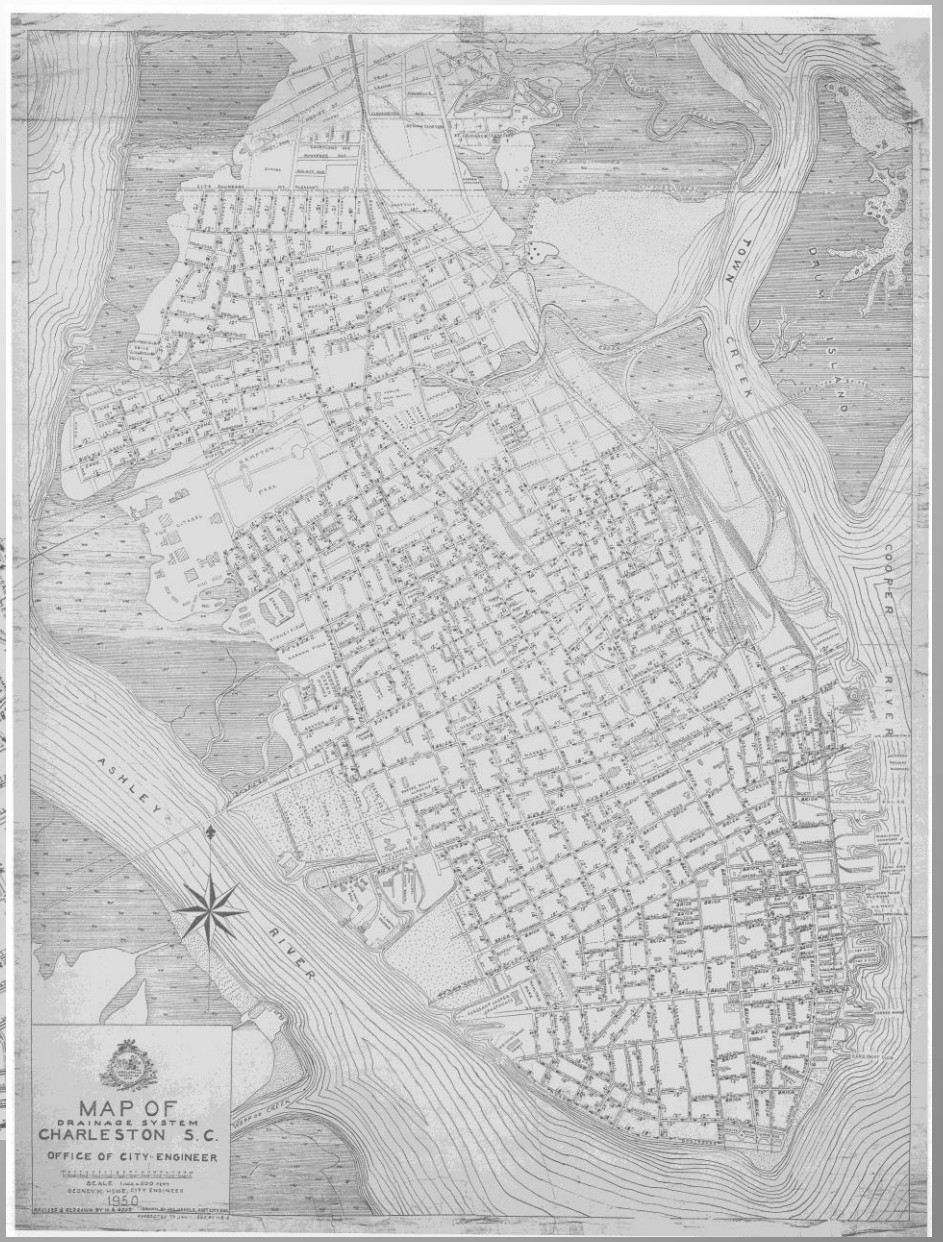
- "The present plan of draining the City, was unequivocally condemned, and an improved system declared to be indispensable to the health, comfort and convenience of the citizens."

June 1,1859 Plan of New Tidal Drains as now Built by the City Council of Charleston

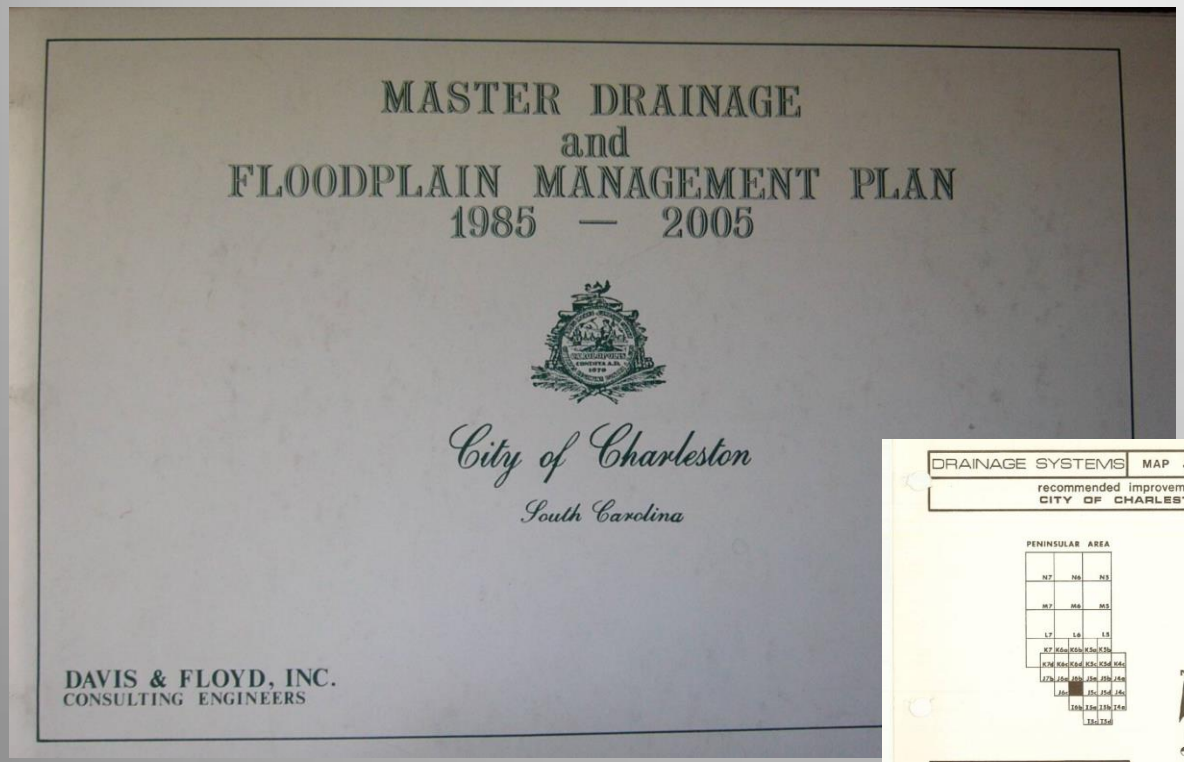


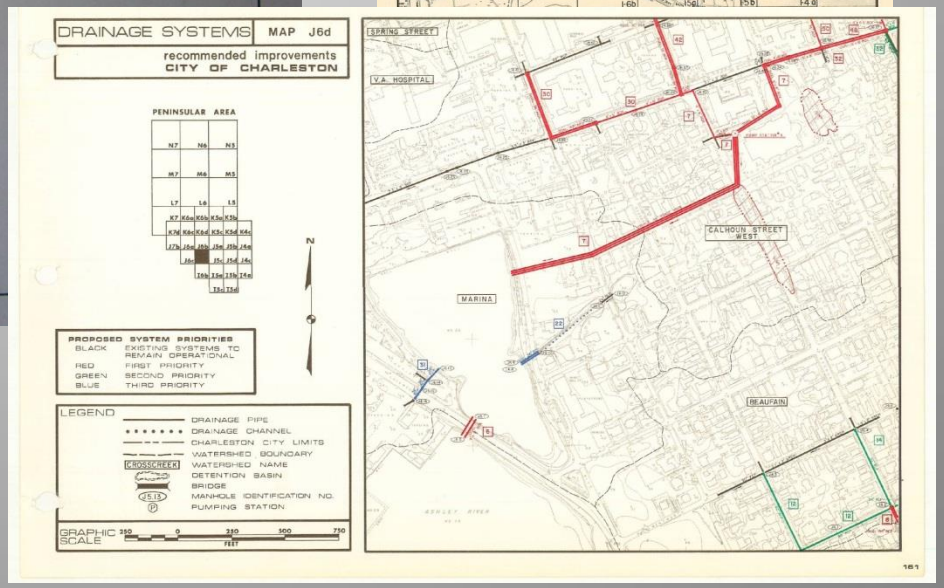
1878 Map of Tidal Drains

Interconnected network of undersized pipes and drains

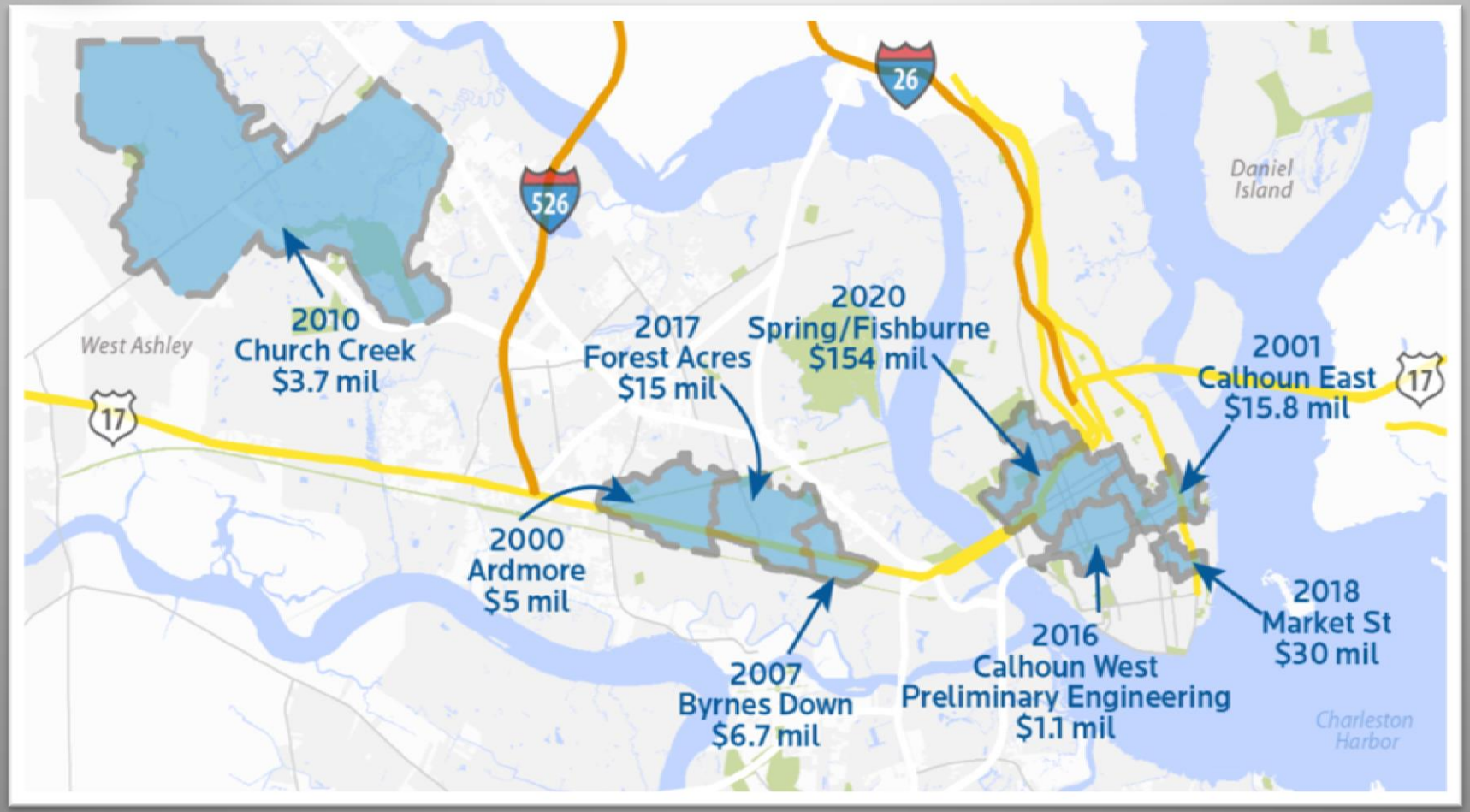


1984 Master Drainage and Floodplain Management Plan





Major Drainage Improvement Projects



Sea Level Rise STRATEGY

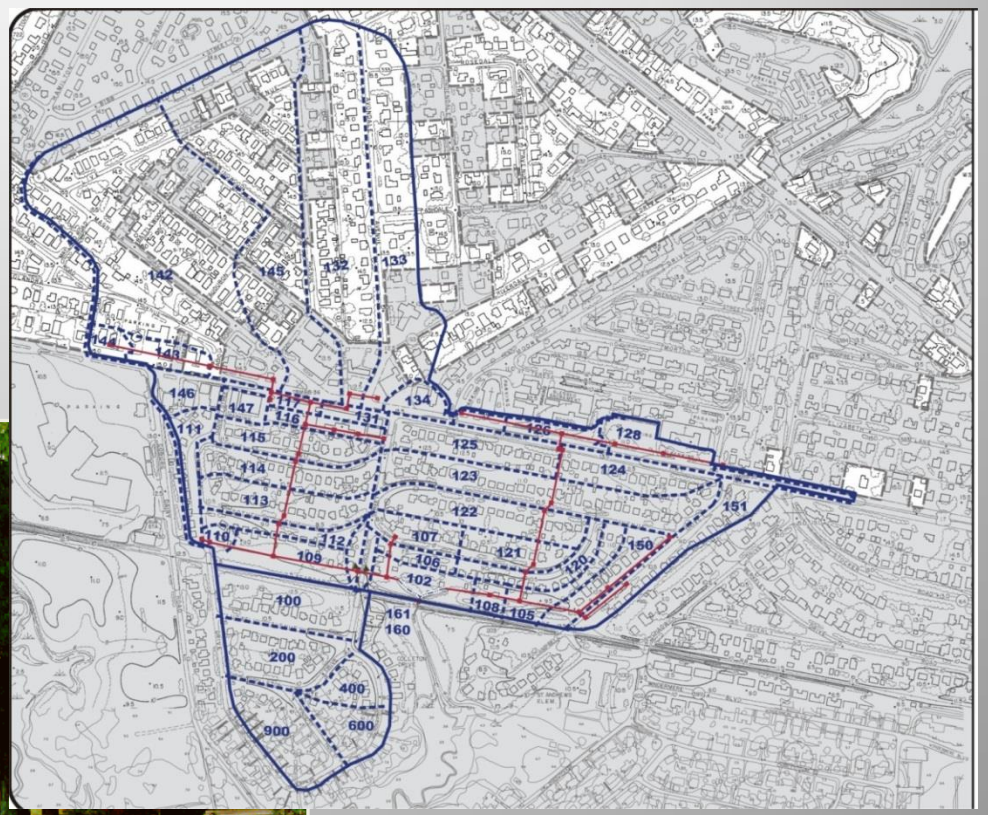
Gravity, Capacity and Storage

Ardmore Drainage Improvements Completed 2005

- 11 acres of detention ponds
- 5x9.5 and dual 5x8 box culverts
- $5,048,000

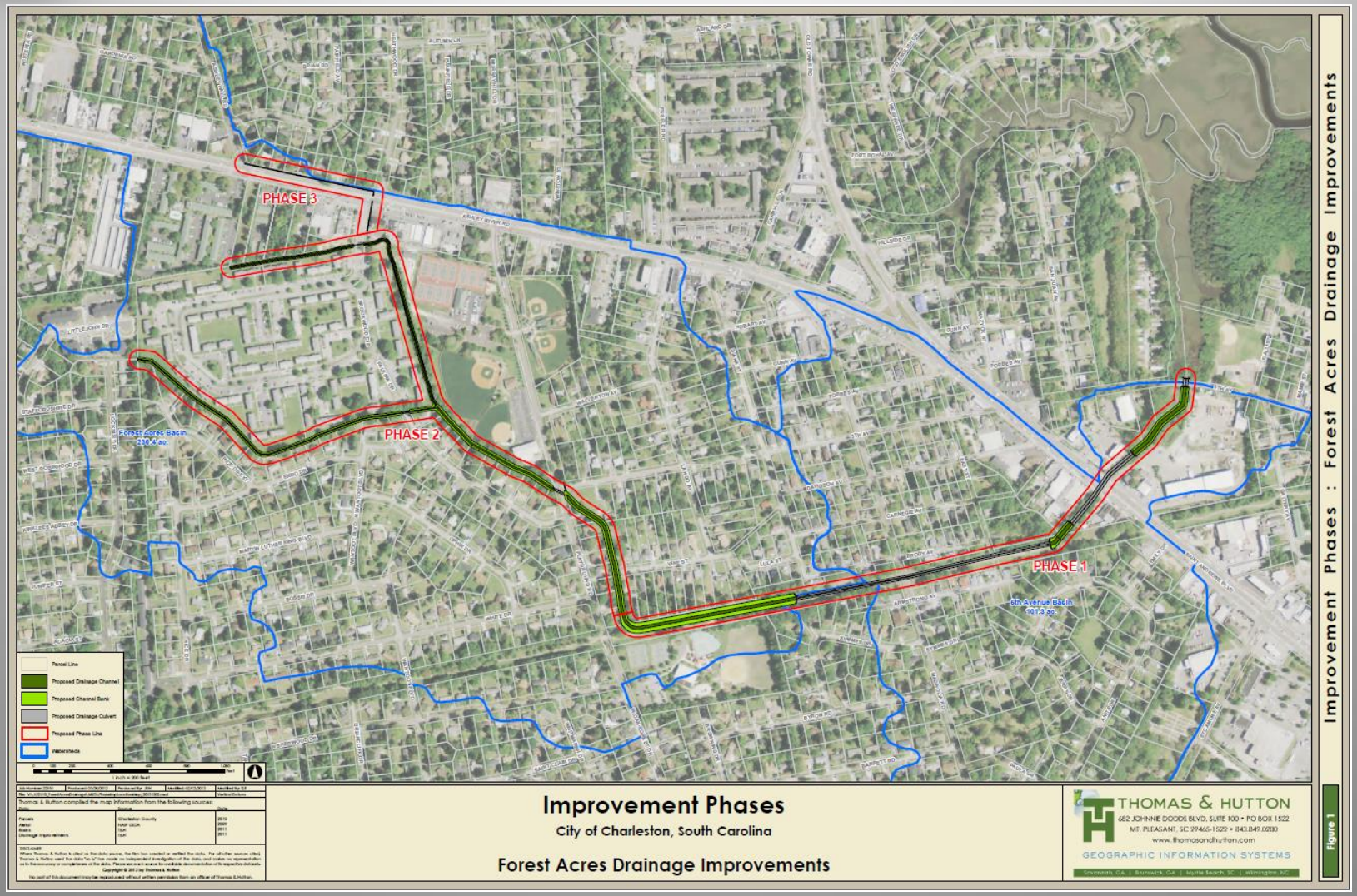
Gravity, Capacity and Storage

Byrnes Down
Completed 2007
$6,683,561

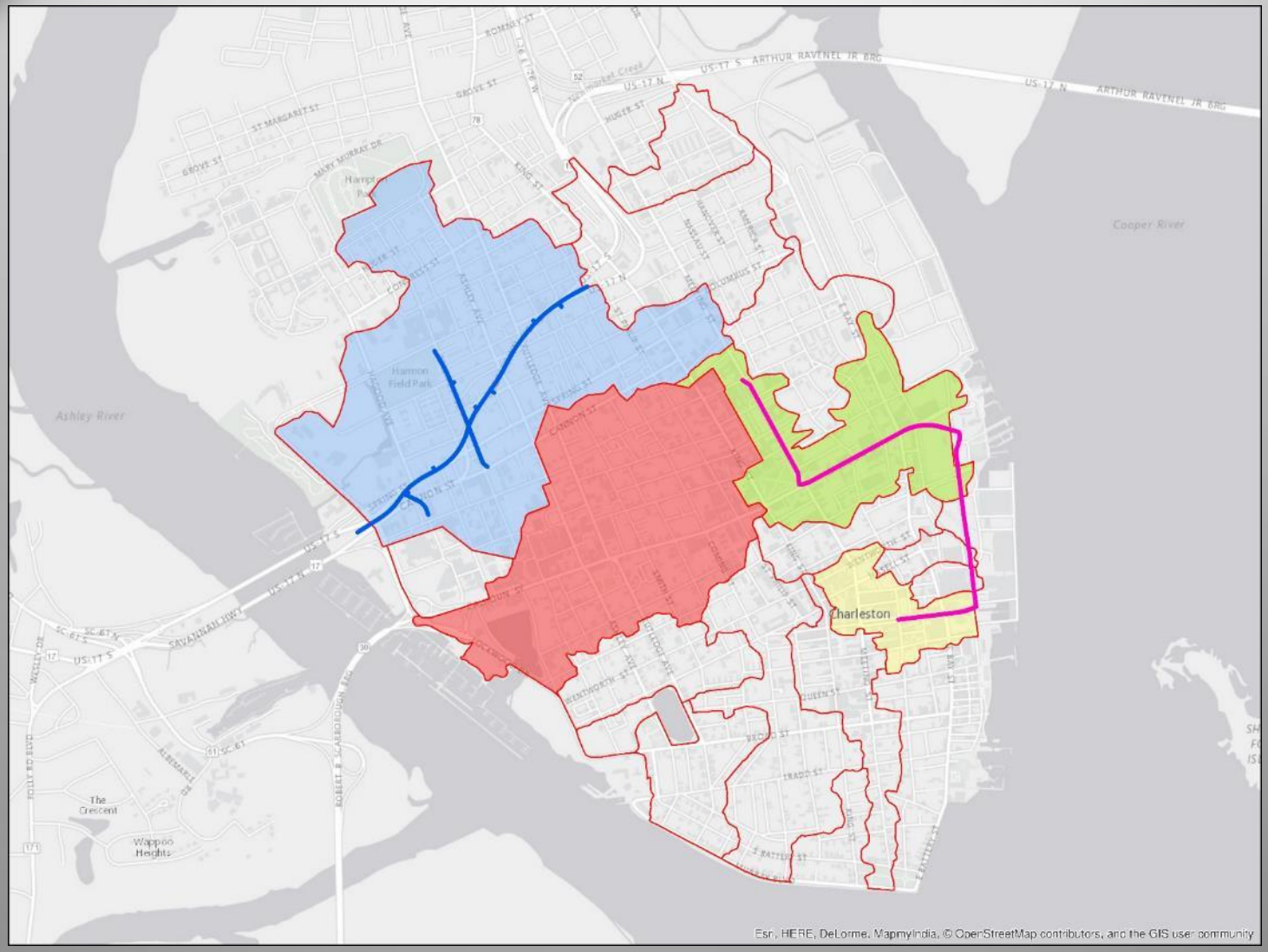


- 10,000 lf of box culvert and pipes
- Largest box culverts were 4x7 and 5x6 ft.

Gravity, Capacity and Storage



Tunnel Collection and Pumping



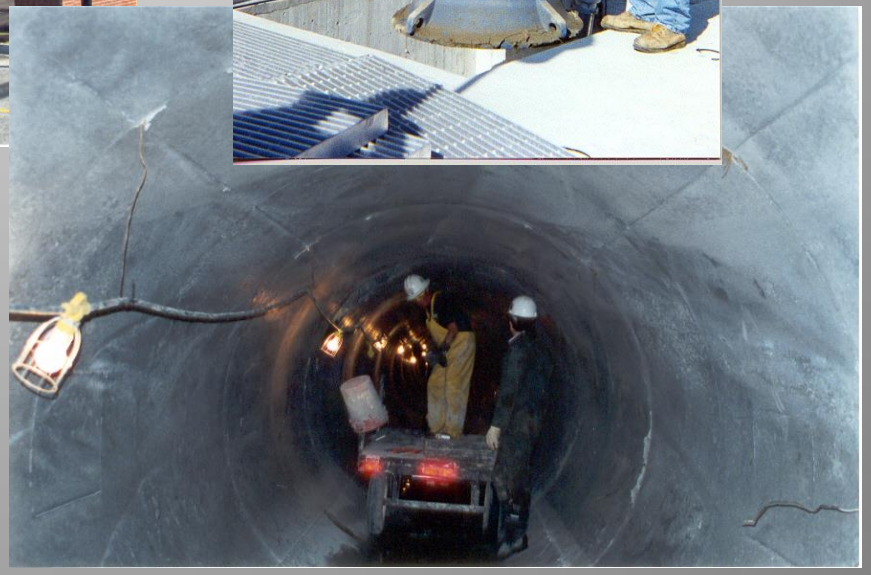
Tunnel Collection and Pumping

Calhoun Street Drainage improvements

Completed 2001

10 ft. and 6 ft. Tunnels

Tunnel Collection and Pumping



Calhoun Street
Drainage improvements

$15.8 million

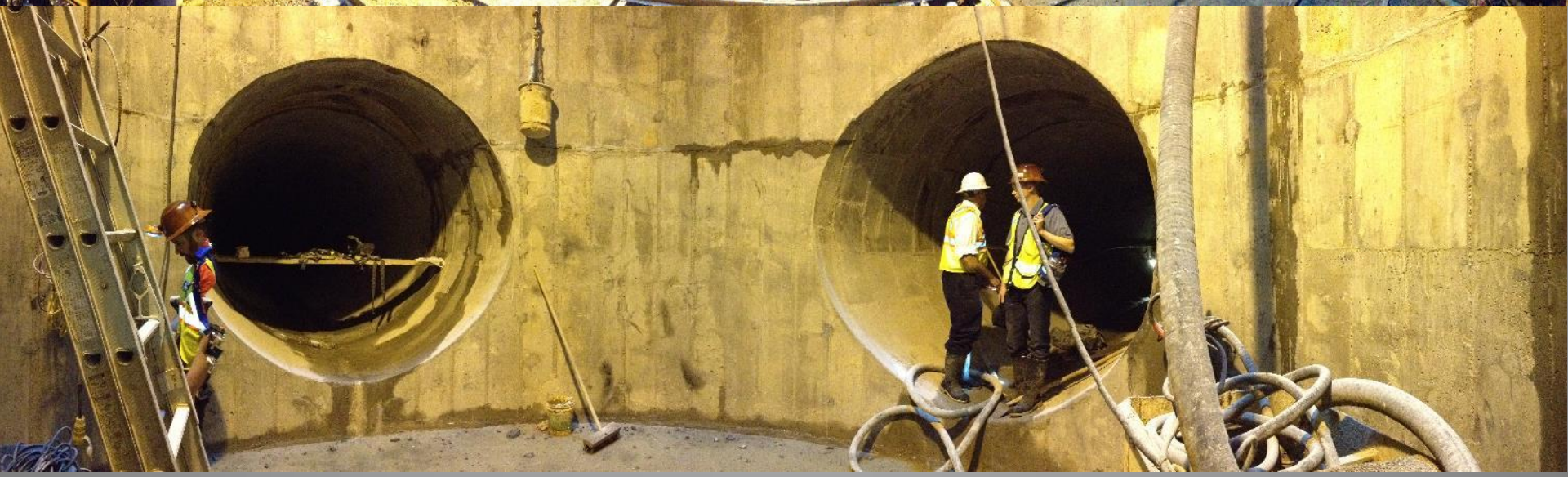
Tunnel Collection and Pumping

Market Street Drainage Improvement Project

Tunnel Collection and Pumping

Market Street Shaft and Tunnel

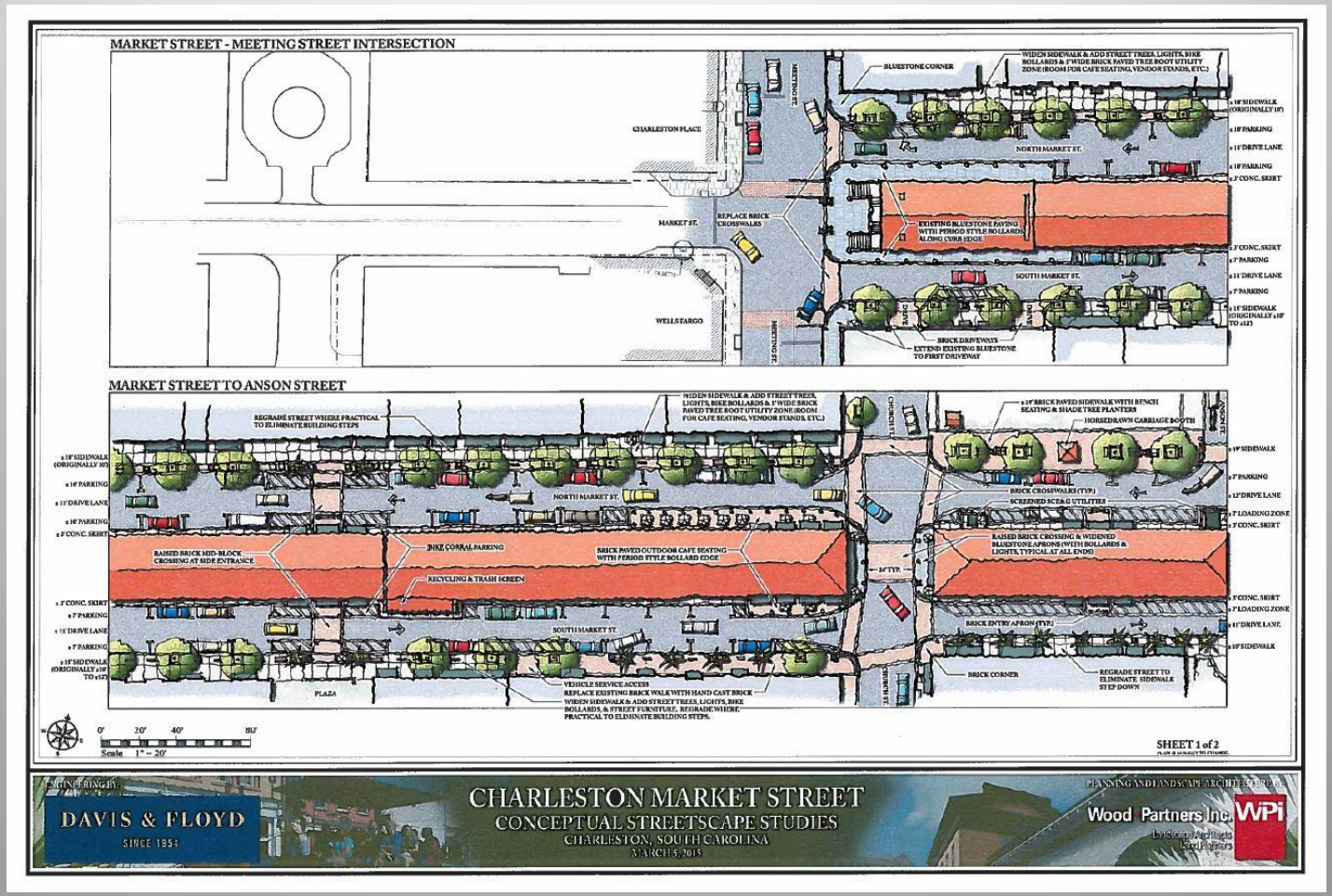
Tunnel Collection and Pumping



Tunnel Collection and Pumping

Tunnel Collection and Pumping

Tunnel Collection and Pumping

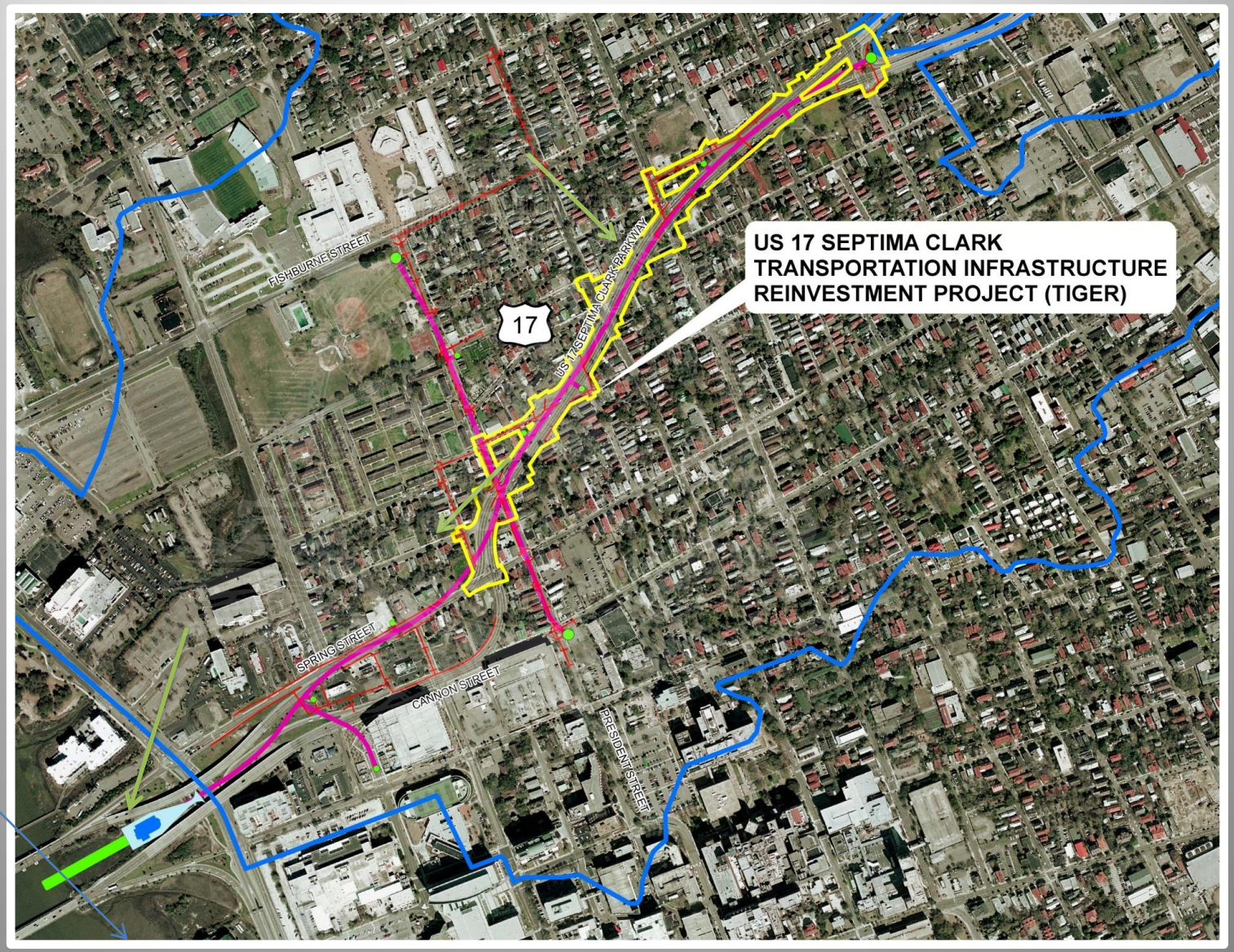


Tunnel Collection and Pumping

Photo courtesy of
Post & Courier

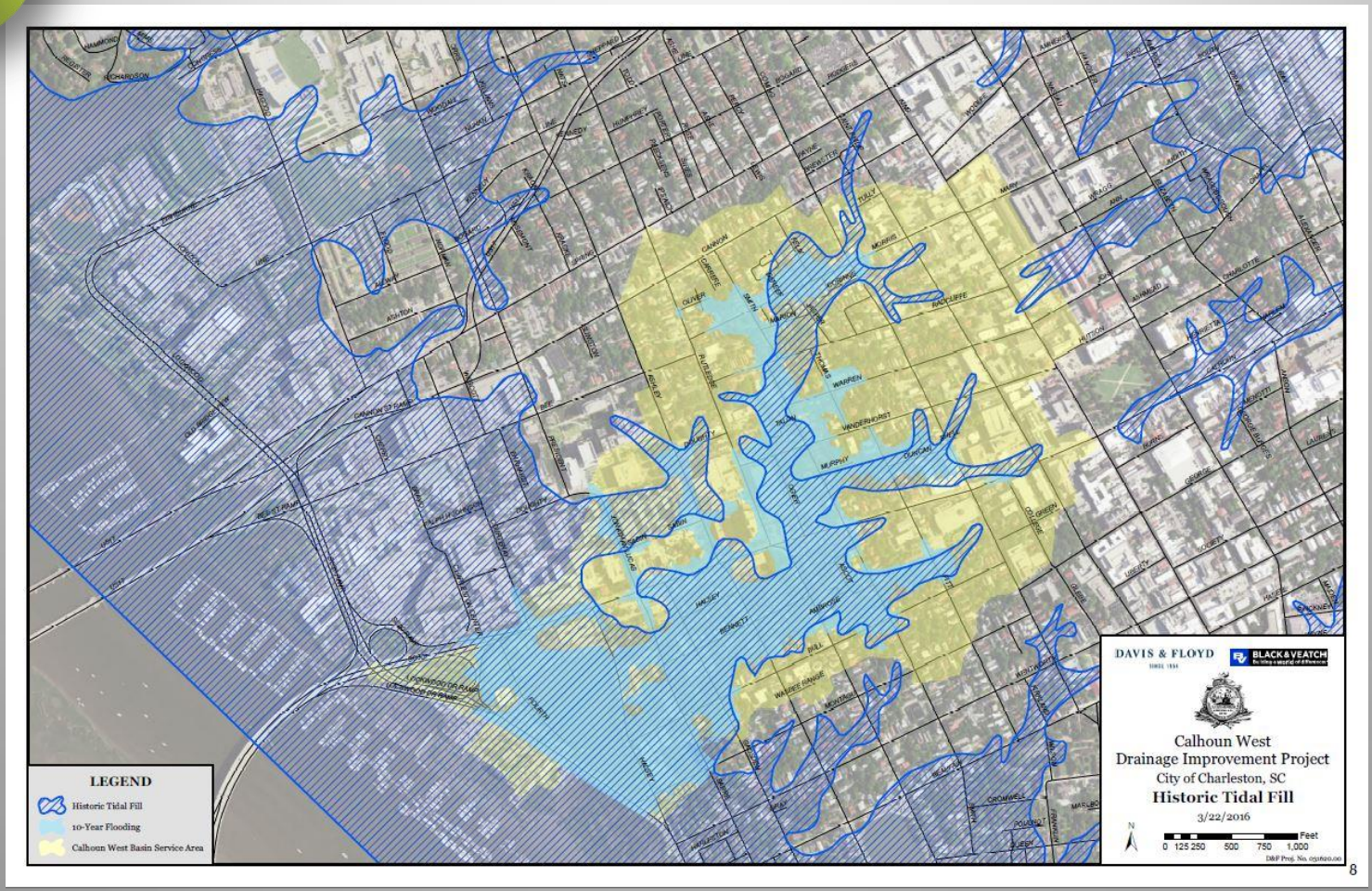
Spring/Fishburne

Tunnel Collection and Pumping



Tunnel Collection and Pumping

Tunnel Collection and Pumping



Calhoun West

Raising Roads, Armoring and Walls

Oct 3, 2015 11 inches of rain and highest tides since Hugo

Raising Roads, Armoring and Walls

Aggressive Funding

- 2 mil assessment dedicated to drainage (1990 approx.) leveraged $9M bond
- FEMA Mitigation Grant – Hugo $2.3 million
- SCDOT Funding $1.5M for Calhoun/East Bay
- Stormwater Utility established 1994 ($6.00 per ERU or about $6.5 million per year)

Ardmore $5,000,000
Calhoun East $16,000,000
Byrnes Down $6,000,000
Spring/Fishburne Engineering $12,500,000
Market Street Engineering $*******

Aggressive Funding

- $110.5M grants and contributions awarded
  - $10M ARRA TIGER Grant
  - $12.5 50/50 Match from SCDOT/FHA
  - $88M SIB
- Balance from the Gateway TIF
- Additional 2 mil dedicated to drainage beginning in 2016 ($2.2 million per year)
- Possible USACOE funding

$235,000,000 Capital Investment Between 1990 and 2020

- $81.1M Complete
- $27.2M Under construction
- $126.9M Funded

- $4.1 2016 Maintenance Budget

Final Comments

- Some areas won't be improved by engineering
- Project would adversely affect more than it would help or cost more than the properties it would effect
- Maintenance would be excessive
- Other opportunities for buyouts, elevation and risk awareness

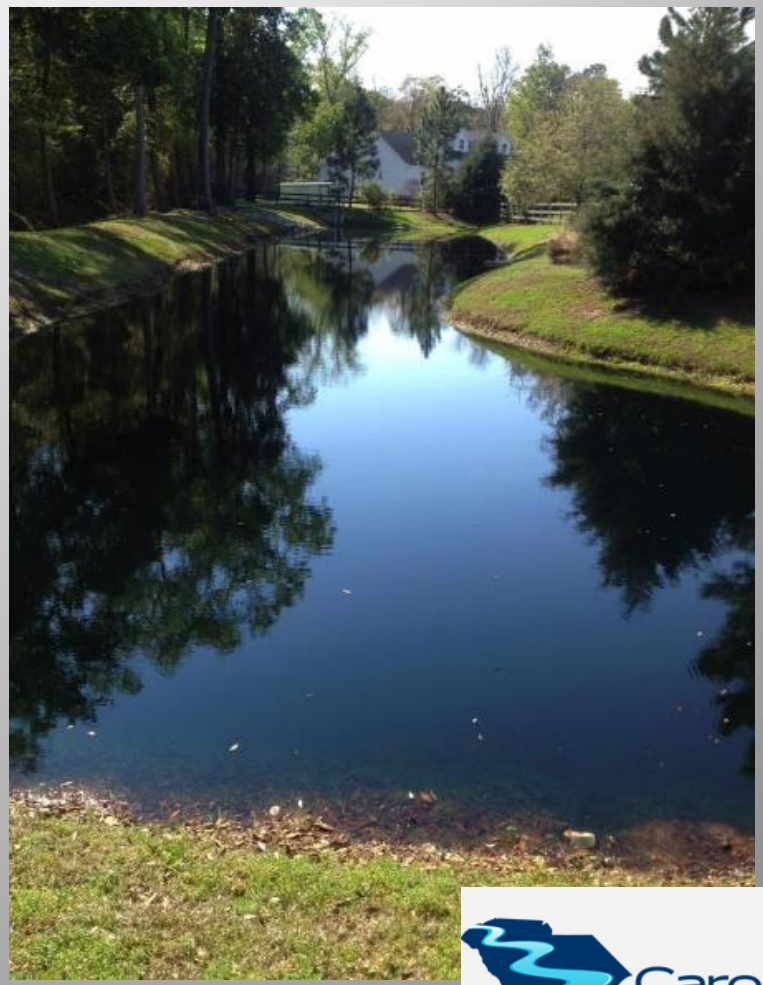
What You Can Do

- **Share importance of this work with elected officials**
- **Share understanding that doing nothing is more costly than being prepared**
- Clean Your Drains
- Manage your Stormwater Pond
- Plant trees
- Capture Water via Rain Barrels
- Install a Rain Garden
- Green Roofs
- Light Impact Development/ Green Infrastructure
- Collective Impact

Clean Your Drains and Ditches

Maintain Your Stormwater Pond

- Inspect
- Control Weeds
- Dredge



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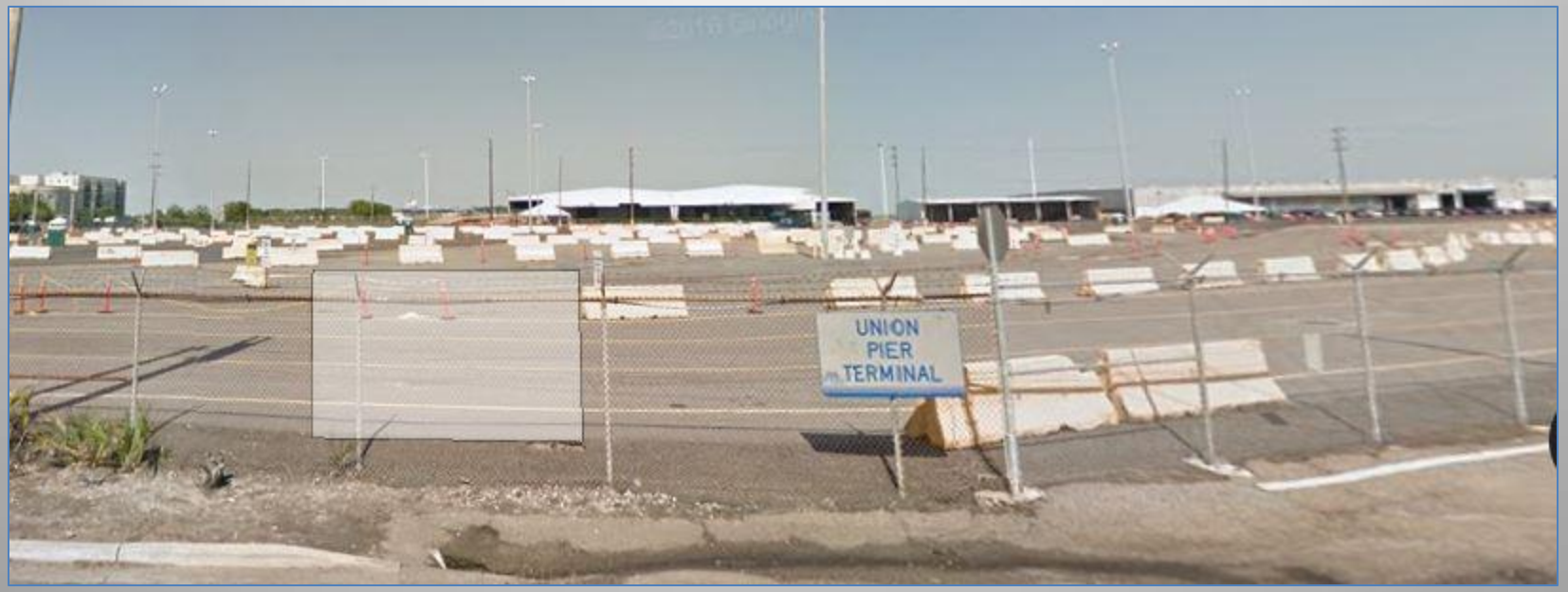
Plant Trees

- Can reduce a city's stormwater runoff by 2 – 7 %

Green Infrastructure Center

Plant Trees



- During a rainfall event of 1 inch,

1 acre of forest will release 750 gallons of runoff,
while a parking lot will release 27,000 gallons.

(PennState Extension).

Capture Water via Rain Barrels

- During a 1 inch rainfall,

a 1000 square foot roof can capture over 600 gallons of water

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Install a Rain Garden

- A planted depression that allows rainwater runoff from impervious urban areas, like roofs, driveways, walkways, parking lots and compacted lawn areas, the opportunity to be absorbed.

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Green Roofs and Green Walls

- Green roofs will intercept between 50 and 60% of rooftop runoff first ½ + inch rainfall

Living Shoreline

- 15 feet of marsh can absorb 50% of incoming wave energy

Collective Impact

- Chesterfield Heights in Norfolk, Va
  - Under street cisterns with permeable paving
  - Downspouts connected to cisterns
  - Basement cistern waste storage units
  - Rain gardens/bio swales
  - 2000 ft living shoreline
  - Reduced flooding by 90%

Tidewater Rising Resiliency Design Challenge – Need and Opportunity

SEA LEVEL RISE

Chesterfield Heights

The sea level rising crisis is a worldwide problem that many are attempting to solve while the Hampton Roads area is second in the nation to suffer. Our focus is on an overlooked neighborhood known as Chesterfield Heights that is located north of the Elizabeth River. Environmental organizations and universities collaborated to resolve the issues the neighborhood faces. The community dealt with frequent flooding and shoreline erosion. Cost is a significant factor in the progression of resolving these issues; therefore the changes should be implemented in stages. Flooding can be reduced by creating underground cisterns to store rainwater. A living shoreline will be applied to the waterfront in order to maximize the erosion from the shipping channel. The final result is raising the entire home to save it from flooding. Mitigating with sea level rise rather than resisting its inevitable impact is preferred in the overall neighborhood design.

01 MITIGATION

$120 million- HUD National Disaster Resiliency Competition

03 UNDER STREET CISTERN

04 RAISE THE HOUSE

TEAM MEMBERS

WETLANDS WATCH

WWW.WETLANDSWATCH.ORG

Sea Level Rise

Local Initiatives

- Charleston Resilience Network
- SC Aquarium Resilience Initiative Coastal Education
- Urban Land Institute - Resilience Study
- Enough Pie - Awakening King Tide
- Carolina Clear – Clemson University
- The Nature Conservancy
- National Audubon Society
- Pew Charitable Trust – Flood Prepared Communities
- Many more

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Kim Counts Morganello kcounts@clemson.edu

Read it: Sea Level Rise Strategy
http://www.charleston-sc.gov/DocumentCenter/View/10089

View it: Sea Level Rise Viewer
http://gis.charleston-sc.gov/interactive/slr/